VOL. 1. DECEMBER, 1914. PART 2.

TP540
I58
P49

JOURNAL

OF

THE INSTITUTION

OF

PETROLEUM TECHNOLOGISTS

AND

RECORD OF TRANSACTIONS.

FOUNDED 1913—INCORPORATED 1914.

PUBLISHED BY
THE INSTITUTION OF PETROLEUM TECHNOLOGISTS,
17, BASINGHALL STREET, E.C.
AND PRINTED BY
CROWTHER & GOODHAM,
124, FENCHURCH STREET, LONDON, E.C.

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NOTICES.

The Institution as a body is not responsible for the Statements or opinions expressed in any of its Publications.

Copyright. The entire contents of the Journal are covered by general copyright, and official permission is necessary for reprinting long abstracts; but editors may use not more than three pages of any paper, provided that credit is given at the beginning or end, thus:—"Reprinted from The Journal of The Institution of Petroleum Technologists."

Issue of Journal. Notice of the publication of each part of the Journal is contained in the first subsequent circular issued to the members, and in case of non-receipt, immediate intimation should be given to the Secretary. Additional copies of any parts can only be supplied to members on payment of 5s. each, plus postage; but cannot even then be had if the parts have been stitched together into volumes.

The Memorandum and Articles of Association, and the By-laws and Regulations of the Institution were published in the June issue of the Journal, and will in future be published in the first issue of every session.

Change of Address. It is particularly requested that members notify the Secretary immediately, of any change of address; and members are also requested to advise the Parcel-Post Department as well as the Letter Office, of any temporary change of address, as, unless this is done, parcel-post packets will not be re-addressed; but will be returned to the office of the Institution in London, thus incurring further expense for postage.

The Library. A list of books already presented to the library of the Institution is published in this issue. The thanks of the Institution are due to the donors. Further gifts of books will be highly esteemed.

To Authors of Papers. Papers should be clearly and legibly written, and the copy should be carefully corrected by the author before it is presented.

All drawings, diagrams or other illustrations should be in such a state as to admit of direct photographic reproduction.

All quotations, technical terms, and localisms should be indicated by means of inverted commas.

All foreign weights, measures, and costs should be given whenever possible; and also their English equivalents.

It is suggested that authors append as complete a bibliography of the subject treated, as may be possible.

All papers and notes submitted to the Institution are supposed to be original communications unless distinctly stated to be otherwise, in which case the exact reference to the previous publication should be given.

Advertisements in the Journal. A limited number of advertisements of firms interested in the Petroleum Industry, may be inserted in the Journal. Applications for terms, etc., should be made to the Secretary.

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PERSONAL NOTES OF MEMBERS, AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

The President and Lady Redwood gave a Garden Party on the 18th July, at their residence, The Cloisters, Avenue Road, Regent's Park, to the members of the Institution and ladies, to meet the Vice-President and Lady Cowdray, and, the weather being fine, an enjoyable afternoon was passed in the old-world garden of The Cloisters, enlivened by the strains of an excellent band. There was a large demand for the services of Madame Claire on the part of those who desired to look into the future, and the more active of the visitors engaged in clock-golf and quoits, which Lady Redwood had rendered additionally attractive by providing prizes.

Nearly all the members who were in this country at the time were present, and the two hundred guests also included Rear-Admiral Sir Edmond J. W. Slade, K.C.I.E., K.C.V.O., and Lady Slade, Sir Frederick W. Black, C.B., Director of Navy Contracts, and Lady Black, Sir William Phipson Beale, Bart., K.C., M.P., and Lady Beale, Major O'Meara, R.E., C.M.G., Lieut.-Col. Sir Charles H. Bedford, D.Sc., M.D., and Lady Bedford, Col. and Mrs MacGeorge, Dr. S. Mullineux Walmsley, Mr. Charles E. Musgrave, Secretary of the London Chamber of Commerce, and Dr. Dugald Clerk, F.R.S.

The sympathy of the members will be extended to the Vice-President, whose third son, the Hon. Geoffrey Pearson, has met his death while serving his country at the battle front in France.

Mr. Pearson, who was only 22 years of age, had since leaving Cambridge occupied himself in gaining technical experience to fit him for the position to which his ability and energy entitled him. One who knew him well writes of him as follows :—

"He died gallantly on active service, and was working with the Mechanical Transport which has done so much to keep our Army in the field efficient and effective. Our Mechanical Transport and the organiza-

tion connected with it is the marvel of the French military authorities. Mr. Pearson had many motor wagons under his control and superintendence, and both officers and men with whom he came in contact spoke most highly of his capabilities and hard work. His loss is very greatly mourned amongst them. There is a sincere feeling of sympathy on the part of the Field Marshal and officers at the front with Mr. Pearson's family in their loss."

Professor JOHN CADMAN, M.Inst.P.T., returned from Trinidad in September.

Mr. JOHN CAMPBELL, M.Inst.P.T., paid a visit to England, and left at the end of September for Lobitos, Peru.

Mr. A. E. CHAMBERS, M.Inst.P.T., returned to Mexico at the end of August.

Mr. E. H. CUNNINGHAM CRAIG, M.Inst.P.T., has returned from Canada.

Mr. ARTHUR W. EASTLAKE, M.Inst.P.T., has completely recovered from his serious illness.

Mr. F. ESLING, A.M.Inst.P.T., is now acting as Chemist to the Burmah Oil Company.

Mr. JOHN E. MARSHALL HALL, A.M.Inst.P.T., has recently returned from New Brunswick.

Dr. WILLIAM HOPE HENDERSON, M.Inst.P.T., the Hon. Secretary to the Institution, has been granted leave of absence, and is paying a visit to the California oilfields.

Mr. F. A. HOLIDAY, A.M.Inst.P.T., returned from Russia early in November.

Sir THOMAS H. HOLLAND, K.C.I.E., F.R.S., M.Inst.P.T., attended the meeting of the British Association in Australia, as President of the Geological Section, and has returned to this country.

Mr. S. LISTER JAMES, A.M.Inst.P.T., has returned from Persia.

Mr. F. PALMAR, the Acting Assistant Secretary, has joined the Honourable Artillery Company, and is now in camp.

Mr. BASIL F. MACRORIE, M.Inst.P.T., has returned from Trinidad.

Mr. J. J. WHITEHEAD, M.Inst.P.T., has reached England from Galicia, the journey from Lemberg (Lwow) occupying sixteen days.

A Meeting of the Institution will be held at the House of the Royal Society of Arts on Thursday, December 17th, 1914, at eight p.m., when Professor John Cadman, D.Sc., M.Inst.C.E., Member, will read a paper entitled "Notes on the development of the Trinidad Oilfields."

The chair will be taken by the President.

The following gentlemen have been nominated (subject to confirmation by the Council) for Membership:—Andrew Campbell, Charles Erik Capito, George B. Reynolds, Ernest Edward Rigold, Ivan A. Stigand (transference to Membership), and Norman Sutherland.

It is with deep regret that we hear, just as we go to press, of the decease of one of our Founder Members,

Mr. W. H. MacGARVEY.

We propose in our next number to give a short sketch of his distinguished career.

EDITORIAL.

The Institution and the War.

Great historical events have occurred since the publication of the first issue of this journal in June of this year, and the Institution has been called upon thus early in its career to decide whether, in view of exceptional circumstances, its activities ought to be in any way suspended or directed into other channels. As to the first of these alternatives, the Council is unanimously agreed that the Institution should adopt the motto, "Business as usual," and should endeavour, so far as lies in its power, to continue the work of which so successful a commencement has been made. At the same time, it has been felt that exceptional circumstances might call for exceptional measures, and that the Institution should at least offer its services to the Government in case of any developments arising in connection with which its advice or assistance could be usefully accepted. With this object in view, the following letter was addressed to the Secretary of State for War on September 18th:—

"SIR,

At the Council Meeting of this Institution, held on Wednesday last, it was unanimously agreed that the services of this Institution be offered to you during the War, for the purpose of nominating Petroleum Technologists, who would be willing to place their knowledge and experience at the disposal of the War Office in all matters connected with petroleum.

I am, Sir,
Your obedient Servant,
(Signed) BOVERTON REDWOOD,
President."

The following reply was received on September 21st:—

"SIR,

I am directed to acknowledge the receipt of your letter of the 18th inst., and to thank you for your kind offer to place the services of your Institution at the disposal of the War Office in all matters connected with Petroleum.

In reply, I am to say that although at present the War Department do not propose to avail themselves of your services, should it be necessary on any future occasion to do so, they will be grateful for your assistance.

I am, Sir,
Your obedient servant,
(Signed) J. d'E. COKE—Staff Capt. for Brigadier-General, Director of Supplies."

A Library of Petroleum Technology.

In the first issue of this Journal members were invited to present to the Institution books on petroleum technology, with a view to the formation of an adequate library on the subject. Elsewhere in this issue we give a list of books already received, and we hope that these may be regarded as forming the nucleus of what will in course of time become a valuable and comprehensive collection. The objects of this Institution being to some extent at least educational, the importance of a good library is sufficiently clear, and it is also evident that the library should contain not only books dealing directly with the subject, but also useful works on collateral subjects.

As Sir Boverton Redwood pointed out in his presidential address at the inaugural meeting of the Institution, petroleum technologists comprise engineers, geologists, and chemists. Consequently, it is desirable not to limit the scope of the library too strictly, but rather to make it inclusive of all those sciences in which petroleum technologists are directly or indirectly interested. The Hon. Secretary will be pleased to give advice to members who are in doubt as to whether works which they may be willing to present would be acceptable.

The Press and the Journal.

As an illustration of the uniformly favourable tone of the notices of the first issued Part of the Journal which have appeared in the public press, the following is reprinted from *Gas and Oil Power* for October 29th:—

"The admirable form and contents of Vol. I, Part 1, of the *Journal of the Institution of Petroleum Technologists* is not only an indication of the early vigour of that very promising Society, but must be in itself a source of strength to further the progress of that valuable Association. With Sir Boverton Redwood, Bart., as its first President, and Lord Cowdray as Vice-President, the Institution has already about 150 members, associate members, students, and associates, besides, we note, two honorary members, Dr. D. T. Day, of the United States Geological Survey, and Dr. Carl Engler, of Germany. The first issued Part of the Journal, which is priced at 5s. to non-members, contains, beside a full list of members, by-laws, articles of association, and editorial and news sections, three papers, one by Sir Thomas Holland, on 'Some Geometrical Features of the Anticline,' another on 'The Educational Aims of the Institution,' by Mr. E. H. Cunningham Craig, and the other on 'Petroleum Technology as a Profession,' by Professor Vivian B. Lewes."

In the absence of the Hon. Secretary, Mr. Horace Wyatt, Secretary of the Imperial Motor Transport Council, has very

kindly undertaken to edit this second Part of the Journal, and the Council desire to place on record their appreciation of the value of the services thus rendered to the Institution.

The American Petroleum Society.

Circumstances similar in the main to those which brought about the founding of the Institution of Petroleum Technologists have led to the recent formation of the American Petroleum Society. Since 1907, the Bureau of Mines has undertaken, in the United States, a comprehensive study of petroleum and its products, but the value of the results has been seriously affected by difficulties in the way of securing hearty co-operation from the men engaged in the industry. Consequently, during the summer of 1913, meetings were held which resulted on September 10th of that year in the formation of the American Petroleum Society. This Society was organised primarily for the purpose of gathering together the general knowledge on petroleum at present in possession of the many men interested or engaged in the industry, in order that this knowledge might be co-ordinated and arranged, and, by systematic and united study and research, further increased. The Society will consider primarily subjects relating to the science and technology of petroleum and its products, bearing in mind at all times the desirability of making technological studies of direct and pertinent value to the industry. It will act as a clearing house and arbiter of standards on behalf of the leading associations of the petroleum trade of the United States. Its objects appear to be less directly connected with educational matters than those of the Institution of Petroleum Technologists. The American Society proposes to form Committees, with a view to arriving at standards in respect of which disagreement at present exists. Thus, for example, some standardization is necessary, in view of the large number of different methods now employed for the determination of the flash-point of oil, and similar work is to hand in connection with the means employed for ascertaining the viscosity of lubricants. It is not anticipated that the financial requirements of the Society will be great, as the whole of its officers are giving their services without fee. The first annual meeting was announced for October 15th, 1914, at New Orleans, while the second is due to be held at San Francisco in October of next year. On that occasion, it is intended that the Society shall act as host at the World's Petroleum Congress.

The Influence of Petroleum Products on Modern Warfare.

For the first time in history, a great war is being fought under conditions which render the maintenance of supplies of petroleum products not merely a valuable accessory, but one of the prime factors of successful tactics and strategy. All the armies engaged are very largely dependent on mechanical transport, which in its turn is dependent upon the supply of petroleum products. Petroleum spirit has made possible in the first instance the road motor vehicle, and more lately the airship and aeroplane. These last are in the nature of new weapons of offence, which for the first time make it impossible for residents in Great Britain to regard Continental warfare with an air of complete detachment. The sea still protects us from the greater dangers, but the possibility of an aerial attack is too clear to be negligible. To this degree, the petroleum industry is unfortunately indirectly responsible for exposing peaceful citizens to undeserved danger. Raids on unfortified towns cannot, however, be regarded as the chief uses of aircraft, which have established beyond dispute their enormous value as a means of ascertaining the disposition of an enemy's troops, and preventing an unknown concentration at some vulnerable point. An efficient service of air scouts renders a surprise on a really large scale almost impossible, and tends to convert warfare from short decisive actions into the long siege battles which are the most noteworthy characteristic of the present contest.

From the quantitative standpoint, the use of petroleum products in connection with the war is infinitely greater on land than in the air, since under the modern methods of supply and transport of food and warlike stores to the troops, the bulk of the work is carried on by motor lorries. These operate daily between the railhead to which the stores are brought down from the base, and refilling points conveniently situated behind the troops. The final distribution is still generally done by horsed vehicles, since the type of motor commonly approved for transport work is dependent on the existence of roads, which may not be available at all times and places for the retail distribution of supplies. The use of motor transport vehicles has far-reaching effects. It renders an army far more mobile in two different ways. One of these is that it enables the force to operate at a much greater distance than hitherto from the railway on which it is primarily dependent for its supplies. The other is that the speed capacity

of the motor enables the transport columns to bring up their supplies with sufficient punctuality, however rapidly the troops themselves may be moving. The motor transport columns are more compact than the old columns of horsed vehicles, and one of the former does the work of several of the latter. Consequently, congestion is avoided on the roads behind the armies, and risk of confusion in the event of a retreat is minimised. The average transport motor uses fuel at the rate of one gallon for about seven miles run, and it has been estimated that the British Expeditionary Force alone, without reserves of Colonial troops or new armies, needs about 1,000 such vehicles at its service. This requirement, applying to what is in all only a very small section of the total forces engaged, gives some idea of the enormous quantities of light petroleum fuel now being consumed by vehicles in military service. No mention has yet been made of the enormous number of motor cars used for scouting and in the service of staff officers, of armoured cars, which are proving so useful and ubiquitous, or of the uses of petroleum fuels by submarines and other naval vessels, but enough has been said to show that if dependence had to be placed solely on fuels other than those derived from petroleum, the course of modern warfare could not have undergone the radical alteration which has characterised it.

Since the above lines were written, an excellent example of the importance of petroleum supplies to the British Admiralty has come to hand in connection with the fine exploit of a British light cruiser and four destroyers, which, largely as a result of their great speed capacity, were enabled to catch and sink four German destroyers off the coast of Holland. The "Undaunted," which led the attack, is a light cruiser of 3,750 tons only recently completed. She is oil-driven and is of 20,000 h.p., this giving her a speed of 29 knots. The four destroyers which took part in the action are all of the L. class, of 960 tons, and launched in 1912-13. They have a speed of 29 knots, and, like the "Undaunted," they all use oil fuel.

Petroleum Supplies of Belligerent Countries.

So important has the military motor become, that a shortage in the supply of liquid fuels obtainable by one or other of the combatants might well prove a determining factor in the war. In this connection, it is interesting to note that the home production of petroleum in Germany was in 1911 only about 143,000 metric

tons, the greater part coming from Alsace and Hanover. The production had at that time been practically stationary for four years, so that the figure given probably still holds good with sufficient accuracy. In the same year, the production of Galicia was 1,462,940 metric tons, representing 3·151 % of the world's total production for that year. At the time of writing, Galicia is practically in the possession of the Russians. The supply obtainable by Germany or Austria from Rumania is an uncertain one, and although Germany is probably making use of coal-tar products to a large extent, there is an evident probability of shortage. So far as Great Britain is concerned, the effect of the war in stopping shipments from Russia and Rumania has not diminished our aggregate supplies of petroleum products; for as long as our naval supremacy is maintained, we can freely import from the United States, which in 1911 contributed over 63 % of the world's production of crude oil. In addition we are receiving large quantities from the Dutch East Indies, Mexico, and Persia. Taken together, the whole of the circumstances appear to justify the assumption that if either of the groups of combatants should be severely handicapped by shortage of liquid fuel, our own position and that of our allies is infinitely stronger than that of our opponents.

First General Meeting.

A Meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts on Tuesday Evening, 3rd November, 1914, Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. (President), occupying the Chair.

The Members of Council present were Mr. Edwin R. Blundstone, Mr. Arthur W. Eastlake, Mr. T. C. Palmer, Dr. F. Mollwo Perkin, and Mr. Robert Redwood. There was a considerable attendance of members (some of whom were in khaki), and many visitors.

The President, in opening the Meeting, announced the receipt of telegrams from two Members of Council expressing regret for inability to be present at the Meeting. Sir Thomas Holland telegraphed: "Military duty prevents my attending Institution Meeting. Will make Wilhelm apologise." Professor Cadman also had telegraphed: "Much regret unable to attend Meeting to-night."

In the absence of the Hon. Secretary and the Acting Secretary, the latter of whom was serving his country with the Colours, he called upon Mr. Eastlake to read the list of those who had been elected to the Membership of the Institution since the last General Meeting.

Mr. Eastlake announced that the following gentlemen had been elected:—

Members:—Harold Dabell, Arthur Bertram Hawkins, Ernest Lawson Lomax (transference from Associate Membership) and John Smart Smith; *Associate Members:*—Leonard John Bates, Leonard William Berry, John Albert Child, Thomas Hitchon, William Blomfield Hume, William Joseph Reynolds, and Walter Henry Wilcox; *Student:*—John Arundel Butlin; *Associates:*—Frederick Richard Maggs, and Frederick John Milne.

The President said that, in common with other technical Societies, the Institution had decided, as was said in nautical parlance, to "carry on," and it might possibly be expected that on such an occasion he should make some reference to the important part which petroleum was playing in connection with the war.

The current reports that the German Army was deficient in supplies of motor spirit of themselves indicated how very largely modern warfare was dependent upon petroleum for transport

purposes. The internal combustion engine, in fact, had usurped the position of the horse on the field of battle almost as completely as in the streets of their principal cities.

The daily supplies of food and ammunition to the fighting line were conveyed from railhead by motor vans and lorries, many of which the members had had an opportunity of seeing in their passage through London, and similarly the wounded were brought to the base by the motor ambulances which also had been within their vision from time to time, especially recently. It was, however, more largely as providing the means of propulsion of aeroplanes and dirigibles that petroleum had revolutionised the art of war, because the movement of troops and the range-finding of heavy artillery were now for the first time largely based upon information furnished by the ubiquitous aerial scouts.

In contrast to that which might be termed the legitimate use of a recently created branch of the service which he thought all would agree seemed destined to play an even more important part in military operations in the future, the action of the enemy in dropping bombs on historic public buildings and killing innocent non-combatants was deserving of the severest condemnation, as was also the systematic use of petroleum as an incendiary agent in completing the destruction by fire of conquered towns and villages.

It was not alone on land that petroleum had proved to be so potent a factor, for it was common knowledge that the radius of action of the fleets, and especially of destroyers and submarines, had been very largely increased by the adoption of oil fuel, and thus the naval situation also had undergone a very great change.

Those considerations should lead them to recognise the wisdom and foresight of the British Government in making provision for ample supplies of petroleum products. They also conclusively demonstrated the growing importance of petroleum, and the need for such an organisation as the Institution of Petroleum Technologists, which aimed at providing a body of men qualified by education and training to take part in the further development of the industry in the interests of the Empire.

In the course of the remarks which he was permitted to make at the Statutory Meeting of the Institution, held at the London Chamber of Commerce, he made reference to an invitation which had been conveyed to them at the instance of the German Government to assist in the formation of an International Petroleum Institute which was to have its headquarters at Karlsruhe. He ventured at the time to suggest that judicious procrastination

might be advisable. Though he made no claim to prescience in that suggestion, because it was impossible for anyone to know the developments which might occur, and which, as a matter of fact, had since occurred, he thought at any rate they might congratulate themselves upon the policy which was then adopted by the Council. Where the headquarters of such an International Institute might ultimately be established it was impossible of course to say, but he thought it was quite safe to predict that for at any rate a great many years to come no sane person would think of suggesting that Karlsruhe was a desirable centre for such an Institution.

The papers to be read that evening, as the members would have seen from the notice, were, firstly, one by Mr. Wells, and, secondly, one by Dr. Perkin. Mr. Wells, who would deal with oil field and oil enterprise organisation, was qualified to speak with authority on the subject. He really needed no introduction, at any rate to most of the members. He was well known as having occupied an important official position under the Egyptian Government, which led to his making a special study of the petroleum industry; he had very considerable experience of engineering procedure in matters of that kind, so that he was in a position to speak with authority on the subject with which he was about to deal.

The following paper was then read :—

Initial Equipment and Organisation as Affecting the Ultimate Success of Oil Development Companies.

By John Wells, F.G.S., *Member.*

It is with some diffidence that I venture to read the following paper. The subject is not only of immense importance to the investor, but raises a large number of questions wherein the personal element must of necessity play a very important part. It is easy to dogmatise, but dogmatism will not assist in the solution of a problem which has to be faced by most engineers at some period of their careers.

Despite the desire of the engineer to do the best possible in the interest of those for whom he is working, it often happens that the financial arrangements not only do not permit of his doing so, but lead him into taking risks which are unjustified, and liable to bring both him and his profession into ill repute. It is a moot

point, indeed, how far an engineer is warranted in permitting the directors of an oil development company to take risks, but the fact is that the initial cost on paper of doing a job properly is often so high that, if put forward, it would in many cases deter the adventurers from proceeding.

The greatest difficulty, perhaps, that faces the practical engineer is the fact that the large majority of promoters of oil development companies, and not only promoters, but directorates as well, are absolutely and entirely ignorant as to the methods and costs of exploration and development work. As a whole, their first object is to reduce the working capital to the lowest possible limit, and, in order to provide *prima-facie* evidence that this limited working capital is sufficient, they invite engineers to take an undue risk, estimating at too low a first cost. In fact, they will go so far as to ask an engineer what is the average cost of sinking wells in such and such a district, and then utilise the statement as a basis for their calculations for the working capital necessary, omitting altogether the capital necessary for the initiation and organisation of the work before boring operations can be started. Failing an engineer sufficiently well known and compliant, they will perhaps approach local contractors for a price, or will go to the manufacturer of machinery, and obtain an estimate of plant and a rough idea from him as to what he thinks it should cost to put the wells down. As a result, a very large number of exploration and development companies for oil are doomed to failure from the start.

It appears to me that this Institution as a body can, by distribution of the knowledge of its members, be a great help to the investing public; and not only to the investing public, but to its members themselves, in so much that each and every one of them who may be responsible for preliminary exploration, will have a better chance of being provided with the funds necessary to carry out the exploration work on proper lines, thus ensuring a reasonable prospect of completing the initial borings to the maximum possible depth requisite to prove the value, or, at least, the presence or absence of oil.

I have in course of preparation at the moment a book dealing with this subject in a more extensive form than is possible in a paper before the members of this Institution, but I propose in this paper briefly to run through some of the more salient points, and, if perhaps in the course of the paper I appear to dogmatise in any part thereof, I would ask the members of the Institution to accept my apologies in advance, and to believe that my

endeavour is to lay the matter before them for mutual discussion.

In all branches of industry connected with civil engineering, such as bridges, irrigation works, etc., it is customary to prepare specifications for the contractors to tender upon; even then we have only to turn to any large "public" contract to see that the prices for even a hundred thousand pounds contract will vary among the different tenderers to an extent approaching 20 per cent. Now, we must bear in mind that the contractors putting forward prices for a specified undertaking have in their employ experts in nearly every branch of the work. For example, the prices for the smithing work are prepared by the foreman in charge of the smith's shop; again, the platers' and riveters' is estimated for by the senior foreman of that department; the machine work, by the foreman of the machine shops, and so on; each branch is represented by a responsible staff, which has its individual work allotted for estimating; subsequently the head offices add their proportionate charges for overseeing, for interest on capital, plus charges in general, and, finally, the percentage of profit on the undertaking. Despite all these conditions, the prices quoted by perhaps half a dozen firms of eminence will vary to an extent approaching 20 per cent. We can only assume that this variation may be due to differing personnel, or to the location of the works being adverse, or to expensive organisation, or to many other causes more or less directly connected with the general organisation, assuming, of course, that all the different firms are tendering to one specification provided by the prospective purchasers.

If, then, there is this enormous variation in the estimated cost of doing specified work, under conditions wherein every factor connected with the work is known beforehand, we can appreciate the difficulties that beset even the most experienced engineers in dealing with the estimates for exploration work for oil under conditions wherein many requisite data are absent and wherein no ordinary factor of safety or fools' factor is reasonably applicable. Granted, then, that there are always more or less unknown factors, it is all the more essential that the engineers responsible for the estimate shall be in possession of all possible data. To obtain this latter it is essential that the individual specialist shall be made use of and be responsible for the data appertaining to his particular subject, and it will be found to be the exception rather than the rule that the ability of any one engineer will cover all the various branches of the industry. Hence the necessity for

co-operation amongst the specialists in the various branches of the profession.

None the less, however, at least one experienced engineer with a wide general knowledge is essential for the moulding of the integral parts represented by the specialists in this, that or the other branch of the profession. Few men, indeed, attain an universal or general knowledge of the profession as a whole, but the experience of such men is invaluable in adjusting the purviews of the individual specialists. I mean to convey by this, that although the knowledge of the specialist in chemistry may have the highest possible value attached to it, and his projects in the laboratory may be excellent and accurate, yet, though working admirably in the laboratory, he may be a failure in actual practice, either on the score of cost, or perhaps, on account of mechanical difficulties, not necessarily impossible from a mechanical point of view, but impossible from the point of view of commercial mechanism. The specialist has a tendency to become circumscribed in his outlook, and, without intending anything in any way derogatory, it is better in many instances for his results to be put before the general practitioner, as the latter's wider general experience is of value in considering the commercial application of the former's studies and projects.

Thus, then, we agree to bring the work of the various specialists before the general or consulting engineer, leaving him to extract the various valuable features of the different specialists' reports, and mould them into one working and organised entity. It is not an easy business, even for the most experienced engineer, more especially if that engineer is not going to be made responsible hereafter for the conduct of the operations as detailed by him. For this reason it is better that the prospective manager, who is to have control of the work in the field, shall be in direct touch and accord with the general engineer, so that at least one responsible man in the field is thoroughly conversant with the scheme and organisation in all their details.

Talking of a scheme, there is one point of infinite importance which must be recognised from the outset, namely, that few, if any, engineers are capable of laying down a concrete scheme which will not in the long run have to be subjected to considerable variations, and the recognition of this point before starting will be of help right through the conduct of operations, and will often be the means of preventing a fiasco. It may be that a scheme is got out to undertake a certain number of borings, and the whole of the organisation and equipment is arranged to this end; after

the first boring is complete, oil may be found, or data obtained from the boring may be such as reasonably to warrant the reconsideration, if not the entire alteration, of the drilling programme. In either case, some variation of the original scheme will be required. Therefore a certain flexibility is essential to the ultimate success of the work.

Sometimes the financiers arrange the finance before the engineers have had an opportunity to consider fully the work to be done; that is to say, a group of financiers have put in front of them some concession or project, and, before giving the engineers an opportunity to go thoroughly into the matter, they decide the nominal capital of the company, and the proportion of working capital, subsequently asking the engineers to make their work fit the finance provided. Such a procedure is very similar to putting the cart in front of the horse. The cost of developing a territory should be considered by qualified engineers before the finance is in any way arranged; even this will not necessarily mean that proper provision is made, and it may well be that the proportion of "water" capital to the "working" capital is such that under no possible conditions could the company eventuate into a commercial success.

We may briefly consider a type instance, and discuss shortly the various means of arriving at the probable cost of developing a prospective oilfield. We will assume for the moment that Mr. Blank has obtained a concession of some few thousand acres in an undeveloped territory, with sufficient indications of petroleum to warrant careful consideration. Mr. Blank proceeds to put his concession in front of company promoters or financiers, and makes certain terms with them. Mr. Blank is not a qualified engineer in any way, but has found certain things and obtained certain rights, which he now wishes to turn to account. Before the financiers can do anything on a large scale, it is necessary, or, if not necessary, at least advisable, that they should obtain the opinion of experts as to the prospects of the territory, and data upon which estimates may be based for capital requirements. Under the circumstances, they will probably do one of two things, namely:—

(1) Form a small syndicate with sufficient capital to cover the costs of sending out an expert to report generally; or,

(2) Decide to stand the expense out of their own pockets.

This brings us to the first pitfall, namely, the selection of a suitable expert of proved integrity and experience.

This question of selection is, to some extent a question of cost,

and the promoter endeavours to obtain in one person all the virtues that are requisite, or, failing such a person, selects an "oil smeller." I do not mean anything derogatory to the "oil smeller," as no doubt there are individuals who have a latent sense or intuition which enables them to "spot a winner"; it is, however, very obvious to the ordinary commonsense man that such intuitive faculties are hardly to be depended upon in the quest for oil, and though an ignorant man may have been successful or lucky on one field, it is a risky venture to stake public monies on a report of such a member of the community on unknown fields.

As already mentioned, the general practitioner has his position as well as the specialist, and undoubtedly there are occasions when the general practitioner possesses sufficient knowledge and experience to diagnose the probabilities and improbabilities of a particular district in a hurried examination thereof, and undoubtedly a man possessing such capacity or capabilities is deserving of the biggest fee he can obtain for his services. On the other hand, it would be more satisfactory to the investing public if the work of the preliminary examination was divided, and, in lieu of a single expert, other specialists accompanied a general practitioner, so that the work could be divided up under him and under his supervision. Thus, a surveyor would be detailed to prepare the necessary plans of the area; a geologist to do the geological work, and the general practitioner with his knowledge of the engineering side of the work would look into questions of transport, labour, probable cost of the undertaking, type of machinery, etc., suitable for the work. It would not be necessary for the general practitioner to remain on the ground once the organisation was arranged, and he had placed himself *au fait* with the general conditions and circumstances of time and place. Thereafter the specialists would proceed to carry out their instructions, and deliver to him in due course the complete data obtained by them.

Unfortunately, it more often happens that the general practitioner is asked to do the whole of the work without proper assistance in a very limited time, with the result that thousands and thousands of pounds are afterwards lost, as a direct result of the saving of a few hundreds in the first instance. Such a policy is neither to the interests of the profession nor in the interests of the company promoter, and must sooner or later, on account of the failures resulting, lead to periods in which the investing public will only look askance at any project connected with oil.

The second stage we have to deal with is the return of the experts

and the delivery to the promoters of a report; which brings us to the second pitfall.

The promoter often requires a report as optimistic as possible, and, further, demands a short concise report which can be published. Herein lies a difficulty, namely, the condensation of a voluminous study into small space, involving very often the leaving out of important detail and the retaining only of matter which is favourable. The consulting or general practitioner should be made responsible for this condensed report, and equally responsible for the general report embodying the work done by the various experts.

With regard to the two reports, it is advisable that the pith of the summary report should be a plain statement of facts, with possibly a concluding opinion, which should be definite. The general report should equally be a statement of facts, and should avoid all tendency to padding and long-winded discourses on butterflies, bugs and reptiles, theses on oil genesis, etc. On the technical side, especially where costs are estimated for doing work, the detailed estimates should be presented in the form of an appendix, so that the promoters may be assured that the estimates have been properly prepared as a basis for the summary estimates of cost of conducting the necessary operations. Plans and sections in full detail should be presented with a report, and very definite positions of the proposed borings should be marked thereon. Over and over again one comes across reports in which recommendations are made, but in which the location of the proposed borings is omitted. Cases have come in front of me in which several thousands of pounds have been spent in obtaining reports and recommendations, in which, however, concrete information respecting the exact location and position of boreholes has been entirely omitted. This is all very well if the gentleman making the report assumes that he is going to be in charge of the work hereafter, but it should be recognised that differences of opinion may arise between him and the promoters at a later date, or that circumstances might prevail which necessitated his quitting this earth for realms to which no means of communication exist.

We may now briefly consider what should be the contents of the preliminary report; what essential details are necessary to enable the promoters to judge reasonably the ultimate cost of conducting operations; and as to whether the proposed company should be purely one of exploration or one of development?

(1) Are the prospects such as warrant a reasonable supposition that petroleum will be found?

(2) Are the economic conditions such as will permit the commercial development of the properties?

(3) Are the properties, on the other hand, of such a highly speculative nature that exploration work is necessary before any decided opinion can be given as to the prospective value?

For example, it may well be that, owing to the tropical growth and soil covering the whole area under consideration, it is impossible, without recourse to drilling, for the geologist to give any definite opinion on the geological structure. However, for the moment we will assume that the country under examination is sufficiently open to permit a reasonably accurate diagnosis of the geological and stratigraphical features, and that locations for drilling can be made with some certitude that petroleum may be found within a depth of, say, 1500 to 1800 ft. This will bring the technical problem, so far as the boring is concerned, if not within the limit of a portable or light outfit, certainly within the sphere of operations permissible with an outfit of moderate weight.

Our report, then, will deal in detail with the following points:—

(*A*). *Accessibility*, that is to say, the ease with which the property may be approached, and should detail:—

(1) The means available for delivery of plant and personnel at the nearest point on the seaboard.

(2) The facilities, if any, for landing heavy units of machinery at port of entry.

(3) Whether a regular service of steamships is available at more or less frequent intervals to and from the port of entry.

(4) Freight and passenger rates from home ports, or ports of embarkation to port of entry.

(5) The means of unloading and landing the various units.

(6) The climatic circumstances as affecting the landing of machinery.

(7) The distance from port of destination to the proposed drilling sites.

(8) The local facilities for the transport of plant and materials from port of entry to the proposed drilling sites.

(9) What additional facilities are necessary to ensure effective transport of materials at the port of entry to the drilling sites.

(10) A brief description of the existing means of transport.

(11) The condition of road surfaces and contours between the port of entry and the proposed boring sites.

(12) The estimated cost of transport of heavy sections of machinery from port of entry to the drilling sites, with details as to the limit of weight which can be reasonably handled.

(13) Whether such transport can be more economically handled by a transport department possessing its own wagons, rail track, animals, motive power, etc., etc., or whether it will be more economical to handle it through local transport agents or by contract with local owners of draft animals, or by facilities offered by local railways.

(*B*). *A synopsis of the seasons and general climatic conditions*, as to whether certain periods of the year are dry or subject to abnormal rains, which might affect the transport of incoming machinery during certain seasons, and work in general. Finally, as to what the probable climatic effect will be on members of the staff, more especially in reference to imported skilled labour and executive staff.

(*C*). *The general circumstances of local labour*, embracing :—

(1) Facilities, that is to say, the number of people available from which the local supply of labour can be drawn.

(2) As to whether the labour is available in the immediate vicinity of the properties, or whether it will have to be drawn from a distance, and subsequently barracked and provided for on the proposed drilling sites.

(3) The character of the labour, as to whether it is likely to form a useful class of skilled labourer for drilling operations, timber work, smithy work, machine shop, etc.

(4) The religion of the local labourers.

(5) Public holidays or feast days which will necessitate the shutting down of the drilling rigs, etc.

(6) The local hire rates for labourers, carpenters, smiths, mechanics, foremen, etc.

(7) Some idea of the capacity of the local labourers as compared with European labour.

(*D*). *The Government rules and regulations* as affecting the method of drilling, with a summary of important requirements of the Government Bureau of Mines in respect to samples, shutting off water, machinery regulations, etc.

(*E*). *A general survey of the concession*, topographical and geological, including the exact positions proposed for borings necessary for the proving of the territory. These plans to possess sections through the proposed drilling sites, both across the strike of the oil formation and longitudinally, all heights and depths being referred to some definite datum. More particularly, these sections should be absolutely definite as to what are facts and as to what is surmise.

(*F*). *A short detailed account of the general stratigraphical and*

tectonic features, together with sections in detail of the borings to be undertaken; these latter detailing exactly that which is known, and, further, detailing that which is surmise or which is hypothetical. These descriptive sections should contain a very detailed description of known formations, character, hardness, etc., as such information is very necessary for the boring engineer in preparing his scheme for drilling. Information should be given where possible as to the probable depths at which oil may be expected, and should further indicate the depths at which it will normally be necessary to exclude or shut off water strata. Where, or in cases in which, it is impossible to give data which can be relied upon by the boring engineer, it is advisable and, indeed, absolutely necessary that a definite statement be made as to how far the information supplied is hypothetical, and as to how far it can be depended upon. Finally, the statement should contain a definite expression of opinion as to the greatest possible depth which will be necessary in order to prove conclusively the accuracy of the geological diagnosis of the prospective field. This latter factor is of the greatest possible importance, as the boring engineer must decide the capacity and strength of his plants on this latter information.

(*G*). *The class of drilling plant recommended*, whether a single system, or whether a combination of systems providing for all eventualities.

(*H*). *Detailed estimates of the plants and machinery, casings, etc.*, and general equipment which are necessary in order to complete the exploration, drilling down to the estimated depth given in the geological statement.

Now, these detailed estimates of plant, machinery, casings, etc., are a very big undertaking, and they include not only specified detail with regard to the drilling plant and requirements, but, in addition, the whole of the plant and machinery required for the workshop, water supply, general engineers' stores, etc., etc. In the preparation of these estimates not only is a thorough knowledge of the actual requirements of practical drilling necessary, but, in addition, it is necessary for those responsible for the equipment thoroughly to appreciate and understand the civil as well as the mechanical engineering point of view.

So often a drilling plant is decided upon by those not conversant with practical drilling, and based upon a quotation from one or more manufacturers of drilling plant. The result is apparent in almost every instance of exploration work in the continual series of delays which occur, due to breakdowns, lack of necessary details, etc., etc.,

and one has only to follow the course of new companies, published from time to time in the Press, to realise the enormous waste of time and money due to insufficient equipment and lack of essential details. Almost any engineer, however young, can prepare an estimate of some sort, but the preparation of estimates of plant necessary for completing an engineering enterprise, whether for boring for oil or otherwise, is only possible by men who have had sufficient general engineering experience. If I labour somewhat on this point, it is because I realise the seriousness of it, and in working on the frontiers of civilization I have experienced, in common no doubt with many other engineers, the heart-burning resulting from those at home either altering orders given from the field or shipping plant other than that which has been specified, and at the moment I am reminded of one particular instance of visiting a camp in which I found an American boring-master cursing as only such a man can curse, in a vain endeavour to fit together a column of casing which had been supplied by four different suppliers: nearly every pipe had a slight variation in thread so that it was impossible to make up a column for the hole.

It is difficult in a detailed list of equipment for any particular work to avoid unnecessary supplementary details. Many things that are useful are not absolutely necessary, and it requires a very keen sense of judgment, and a very thorough knowledge of the detail of the work to enable an engineer to decide what is and what is not absolutely necessary. It is better in the first instance to list the maximum quantities, and subsequently to pare them, until the whole forms an entity neither over-done nor under-done.

We may now detail roughly what equipment means :—

(1) The type of drilling machine and drilling method must be determined—making provision, perhaps, for both wet and dry methods of drilling—a machine of ample power and strength to carry down the borings to the maximum specified diameter.

(2) The selection of the number of columns of casing requisite for sinking the preliminary test boring to the desired depth, with adequate provision for closing off, not only the water horizons, but possibly oil horizons of minor importance.

(3) The selection of the necessary implements, boring stems, casing shoes, clamps, elevators, etc., etc., which are requisite for carrying the different columns of casing decided upon.

(4) The selection of general appurtenances requisite in connection with the drilling machine, such as poles, ropes, wrenches, pumps, hoses, swivels, chains, etc., etc.

(5) The selection of fishing tools and instruments which are

likely to be required, and suitable for the size of tools and casings in use.

(6) The selection of special implements which, though not absolutely essential for the conduct of the boring operations, provide for certain contingencies which may occur, or instruments, perhaps, for special scientific work, such as a core apparatus and means of determining the dip and direction of strike from core samples of rock from different depths as boring proceeds. Under this category we form an insurance fund against stoppages which may otherwise occur to delay the work.

(7) The selection of necessary spare parts for the rig, for the engine, for the boiler, for the pumps, etc., in which list we include not only parts which normally wear, and have to be replaced as work proceeds, but also certain emergency spares which, though included under "spares," are in reality a portion of the insurance fund.

(8) The selection of necessary casings for the second, third and fourth borings, as the case may be, together with such additional tools and equipment as may reasonably be necessary to make good the wear and tear on tools provided for the initial boring.

(9) The provision of tanks, pipe, pumps, etc., necessary for the water supply both potable and non-potable, and perhaps necessary condensing apparatus for converting waters into potable water for domestic as well as boiler purposes.

(10) The millwrights' and mechanics' outfit and equipment, which will not only comprise the necessary hand tools, but also such machine tools as are decided upon for the repair shop, and, in addition to these, should provide for all ordinary engineers' stores which will be required for the first twelve months of operations. This outfit in general is one which is grossly neglected by 75 per cent. of the profession responsible for the equipment of such exploration work, largely from the fact that a large proportion of the members of the profession are not mechanical engineers, and possess a very limited knowledge of the use of workshop tools and equipments. A well and not extravagantly equipped workshop should be an essential feature of all exploration work, even though it entails the employment of one or more members of staff who are capable and competent to make use of the equipment provided. Even on small exploration work, a small mechanic's equipment costing from 150*l*. to 200*l*. will enable the engineer in the field to keep running where he would otherwise be shut down. Wherever drilling operations are undertaken, there will always be repairs of greater or lesser magnitude, and it is invariably found

that even with the best possible judgment in the selection, especially of fishing equipment, alterations will have to be made in the field to enable the men to cope with the diverse problems which occur directly any boring is in difficulties. Even though a mechanical workshop may be available within reasonable transport distance of the scene of operations, it does not necessarily follow that it will be equipped either with personnel acquainted with drilling tools, or with tools suitable for the reparation of broken implements, or implements requiring considerable alteration.

(11) Clerical and stationery department, including not only general stationery, books, etc., requisite for the proper conduct of accounts and reports, but, in addition, there are the record forms for the borings, the daily report sheets, stores demand notes, stores order notes, stock books, etc., all of which cost money, and must be provided for in the general estimate.

(12) The surveyors' and geologists' equipment, drawing boards, drawing paper, tracing cloth, etc.; a simple chemical apparatus outfit for the testing of rocks, waters, oil, etc.; and last, but by no means least, the necessary provision for recording and keeping samples of the formations perforated in the course of drilling.

(13) Equipment for stables, transport, harness, wagons, etc.

The estimates for the above thirteen sections of equipment is by no means a small undertaking, and will cover many sheets of estimate paper, but without going to all this trouble it is impossible to arrive at anything approaching a precise estimate of the possible costs. It is all very well to say that the experienced engineer can approximate; it is true that he can do so, but even with all his experience he will find himself taking a risk which is liable sooner or later to ruin his professional reputation. A detailed estimate means a detailed scheme, and a detailed scheme means a definite objective, which latter ensures a reasonable prospect of a successful issue.

(*I*). *Water.*—The question of water supply on any exploration work is a matter of infinite importance, and the preliminary report should contain very definite figures concerning the water supply. It may or may not be material that there shall be a supply of potable water, provided an adequate supply of non-potable water is present; as, providing there is a supply of fuel at reasonable prices, the matter of condensing sufficient non-potable water for a supply of water for boilers and domestic purposes is neither difficult nor extremely costly. More particularly is it necessary for the reporting expert to be careful when dealing with small

supplies of potable water, as such supplies are often easily contaminated, and though their use may on paper convey an impression of cheapness, such supplies are very often a grave cause of loss of money and stoppage of the works, giving rise to sickness in the camp, which is dependent upon a supply of potable water immune from contamination; this is more especially important in tropical and sub-tropical countries.

(*J*). *Fuel.*—Fuel may be considered under three headings, namely:—

Coal,
Timber, or
Liquid Fuel.

It is important to give the prices of each of the above delivered at the bore site, and equally important that the characteristics of the fuel should be stated, as well as its calorific value either in calories or British thermal units.

In connection with this question of fuel, definite recommendations should be made as to the power which is most suitable for the particular work, whether electricity, compressed air, or steam, together with the method of generation.

(*K*). *Staff.*—The question of staff is of the greatest possible importance, not only numerically, but in regard to its ability, and especially its individual suitability for the various works to go in hand. An energetic and capable leader is required, and it is equally important for him to have good material under him. As a general rule a well-paid staff (not necessarily extravagantly paid, but well paid) will do better work than an under-paid staff. The staff required will vary according to circumstances under the following headings:—

(1) Manager.
(2) Mechanical staff.
(3) Drilling staff.
(4) Clerical staff.
(5) Transport staff.
(6) Scientific staff, such as geologists and surveyors.
(7) Service of cooks and servants must not be forgotten in estimating the expenses under the heading of "staff."
(8) Local labour, skilled and unskilled, must equally be taken into account.
(9) Medical.

(*L*). *Commissariat.*—The initial report should, if possible, give the closest facts and figures in regard to local commissariat supplies, and the probable cost per head of feeding the staff reason-

ably well. Lack of local produce must be supplemented by adequate supplies from home or outside, all of which must be taken into account in the estimates.

(*M*). *Time.*—The time factor necessary to carry out and complete boring operations is invariably somewhat uncertain, and even with the best possible organisation, plant, machinery and staff, it is difficult to estimate the duration of time necessary for the completion of the initial boring. However, given good organisation with regard to the transport and delivery of materials, and given an adequate staff and working facilities, it is possible with modern-day machinery to estimate fairly closely the probable time which will be occupied in completing the first borehole. There will always be an initial period from the moment when the first order is given for machinery, until the same is delivered and erected, before actual boring can be commenced, the cost of which will vary according to the locality in which the boring operations are to take place. Where transport is difficult, the time required will be longer, and must be allowed for.

The final estimates indeed cannot be completed until the time factor has been worked out.

General.—I have found it of considerable personal convenience in presenting estimates of costs to detail them in the form of a tree, and a scheme put forward in this manner on a large sheet of paper can be more easily followed and understood than the ordinary arrangement of typewritten sheets. But whatever form the summary estimate may take, it is essential that the whole details of the estimates are available as appendices to the main report.

If promoters and others interested in the initial development of oil territory would insist on complete and proper detailed estimates, many disappointments would be saved.

The factor of safety or contingency factor is invariably a difficulty, but no matter how closely or well estimates are drawn some contingency factor over and above the total estimates is invariably necessitated, and, as a matter of business, should be added to the total sum. If this is not done, there is likely to come a period when, perhaps owing to breakdowns of machinery, ill-health of staff, strikes, and delays in general, the operations will have arrived at an interesting stage at the moment when the exchequer has been depleted. This reserve fund should be called up and provided in hard cash. Unfortunately, it is often provided in the form of reserve shares to be issued when wanted, with the result that just at a time when a few thousands extra are essential to see the completion of the work, the money is not forthcoming.

General Scheme for Exploration and Development of Oil and Shale

Concessions situated at ..... for Messrs. .....

General Provisions.

1 — Geological Survey of District.

2 — Research Borings for
- A — Geology and Structure
- B — Petroleum. Depth 1500–2000 feet.

3 — Testing of Shale Area by Shallow Borings and Shafts.

3A — Chemical Analysis and Laboratory Test of Samples. / Determination of Shale Values, by Trial Retortings of 5 to 20 ton Parcels.

3B — Tabulation of Results—Detailed Arrangements of Oil Extraction Plant—Estimates for same—Detailed Scheme and Estimates for Mining Shale and Delivery to Extraction Plant—Estimate of Treatment Costs and Profits.

4 — Headquarter Depot comprising
- *a.* Offices.
- *b.* Laboratory.
- *c.* Retort Plant.
- *d.* Stores Building.
- *e.* Workshops.
- *f.* Survey Office and Sample Store.
- *g.* Motor Lorry Shed.
- *h.* Water Supply Station.
- *i.* No. 1 Deep Drilling.

5 — Staff including
- Field Manager.
- Assistant Engineer.
- Boremasters.
- Secretary.
- Foreman Mechanic.
- Geologist.
- Chemist.
- Retort Foreman.
- Storekeeper.
- General Labour, Skilled and Unskilled.

Time.

1 year provisional. 2 years to complete.

1 to 2 years. 6 to 10 weeks to obtain Plant.

6 to 10 months to complete.

8 weeks to complete.

1 year provisional, thereafter according to results obtained under (3) and (2)

Date ..... 19 *Signed* .....

Sheet No.....

Date..... 19....

Extract Sheet Showing Estimated Cost for First Year, for Exploring and Developing

Oil and Shale Areas at..... for Messrs.....

No. 1. Initial Expenditure or Capital Outlay.

Depot Buildings £1409	Exploration of Shale Areas £2449	Geological Survey £304	Analysis and Test Retorting of Shales £2500	Motor Traction £1500	Workshop and Mechanics Outfit £450

Deep Drilling Outfit £5125	Casing for Deep Bores *a*—1st Hole £1880 *b*—2nd Hole £1450	Initial Equipment, as Furniture, Stationery, etc. £160	Contingencies £250

Total Initial .. £17,777

No. 2. Monthly Expenditure.

Analysis and Test Retorting of Shale £93	Geological Survey £46 14 0	Exploration of Shale £304	Workshop and Headquarters, exclusive of Executive £107 8 0	Deep Drilling, including Staff, Labour, Fuel and General Expenditure £382

Executive and Administration, not including Specialist Fees, Lawyers, Taxes, Rents or Royalties £68	General—Repairs—Incidentals—Transport—Travelling, etc. £80	Contingencies £333·3

Total Monthly .. £1090 2 0

With Contingencies Total Monthly .. £1363 8 0

No. 3. Provision to be made for First Year.

Initial or Capital Outlay, including Contingency £17,777	Geological Survey £560 10 0	Shale Testing and Exploration 8 months av. £397 = £3176	Deep Drilling £3984	Executive—Depot—General £3064 16 0	Contingencies £4000

Total Provision for First Year .. £32,560

Signed.....

D

Estimate of Initial and Running Costs of Deep Drilling Outfit

for Messrs. .....

Sheet No. .....
Date .....19...

Provision to 2000 ft. (Capacity 3000 ft.) Percussion and Core Drilling, Combination Outfit.

Casings

6½ in. Spare Column. 2250 ft.	(30)		
8¼ in. O.D. 2100 ft.	(24–31)	lbs. per ft.	
10¾ in. O.D. 1650 ft.	(32)		£59
12 in. O.D. 1250	(45)		£206
14 in. O.D. 900	(52)		£293
16 in. O.D. 600	(55)		£352
			£310
			£394
			£275
			£1880

Rig Tools and Appurtenances

Extra Heavy Combination Cable and Pole Rig..	£600
100-ton Derrick	275
45 hp. Boiler	190
40 hp. Engine	160
Rotary	60
Pumps	190
Housing	200
Poles	450
Wire Lines	175
Foundations	75
Stratameter	75
Core Apparatus	400
Flush Tools, Shoes, etc.	1000
Cable Tools	800
Fishing Tools	175
Contingency	300
	£5125

Delivered and erected £5125

Running Charges (Day and Night)

Chief Boremaster	£30 0 0
2 Leading Boremasters ..	50 0 0
2 Assistants	30 0 0
1 Smith	12 10 0
Labour	108 0 0
Fuel, 1½ tons per day ..	56 10 0
General Charges, Supplies, Transport, etc.	45 0 0
	£332 0 0

Monthly £332 0 0

Transport and Erection over No. 2 Boring

£150

Casing for No. 2 Hole—say £1450

FIRST YEAR

Rig Tools and Casings £8455

Total £12,489
4000 ft. of Drilling = say £3 2 6 per ft.

12 Months Running Charges £3984

SECOND YEAR

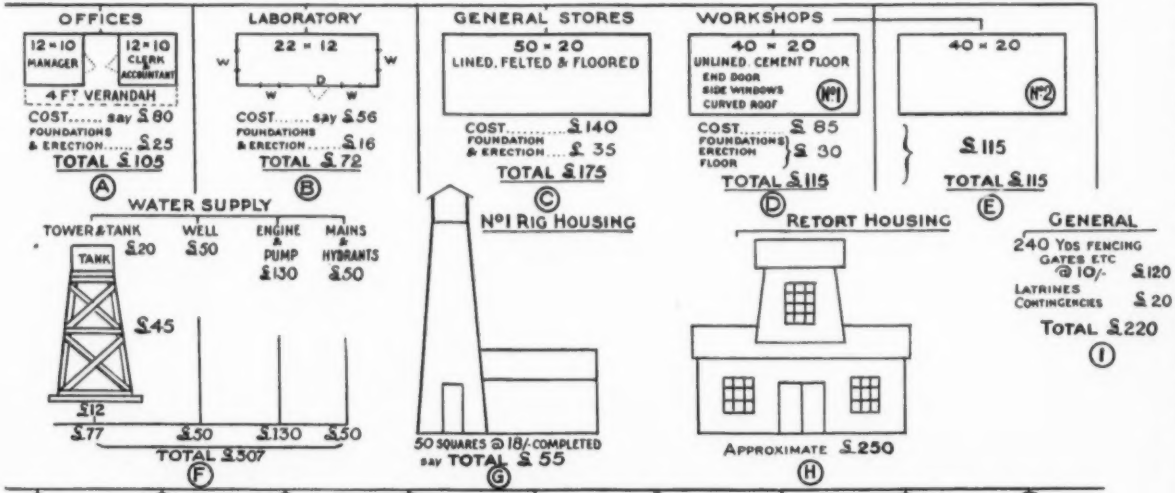
Rig and Tool Additions, Casings £4330

Total £8314
4000 ft. of Drilling = say £2 1 0 per ft.

Running Charges £3984

Estimate of Costs of Buildings required at..... for headquarter depot
for Messrs.....

Sheet No.....
Date..... 19....



TOTAL £1409

Signed.....

D 2

DISCUSSION.

The **President** said the admirable paper which had been read by Mr. Wells formed a fitting link between the abstract generalisations of the papers which had already been read before the Institution and published in the first issue of the *Journal*, and the concrete illustrations of petroleum technology which might confidently be expected to be presented in the papers to be read at future meetings of the Institution.

It might possibly be objected that what Mr. Wells advocated was perhaps in a sense a counsel of perfection, and that in many instances it might be impossible to live up to the high ideal which had been set before them; but that, in his opinion, did not detract from the merit of the communication. If all the members kept before them what should be aimed at, they would be aided and strengthened in maintaining a high standard of procedure.

It often happened that petroleum technologists, through youth and inexperience, or through inability to resist pressure, were led or coerced into taking up an undesirable position, and such men would derive strength from being able to quote such recommendations as those which the author, in the light of his large experience, had made.

Nothing was ultimately gained by underrating difficulties or cost, or ignoring possibilities arising out of unforeseen circumstances. The development of a petroleum field might be, and often was, difficult enough when all the resources of science, mechanical skill and experience were available, and it might easily become a failure if adequate provision for all contingencies was not made. Too often it happened that there was a direct conflict of interests between the petroleum promoter and the technical adviser, for in many cases the former simply desired to present a project attractive not only from the point of view of the promise of a rich yield of oil, but also in respect of the probable expenditure in achieving the result.

Consequently the compliant expert was induced to underestimate the cost, and although, through good luck in the initial operations, the ultimate issue might be favourable, there was no margin for reverses, and the expert might have to bear serious blame. If the author's paper helped only one or two to avoid drifting into that position, he was quite sure Mr. Wells would feel adequately repaid for the labour involved in the preparation of the paper.

Mr. George B. Reynolds, who was leaving for Venezuela in a few days' time, was present at the meeting. That gentleman had had very wide experience in the matters dealt with in the paper which had been presented, and he would therefore ask Mr. Reynolds to be good enough to open the discussion.

Mr. George B. Reynolds said he had been asked to open the discussion on the interesting paper that had just been read by Mr. Wells, and he thought the members of the Institution were to be congratulated on having such a paper read before them, as it put before each class of member—those interested in the financial side of the business and those who were responsible for the actual execution of the work—the difficulties that both had to overcome, the result of which would be the more efficient working of the two together, to the ultimate advantage of both, for success and efficiency depended on mutual understanding and appreciation of the difficulties to be overcome. Personally, as an engineer, he belonged to the second of the two classes he had named, and he looked forward with interest to the book the author had promised. It was from the point of view of the engineer that he personally looked on the questions raised.

As the author had pointed out, it was impossible to dogmatize as to how far an engineer might go in denying himself plant which he might wish to have for the proper execution of his work, for in so denying himself he ran a risk perhaps of failure, or of his work being condemned as too costly, owing to delays incurred by his not having certain tools.

The financial position of those employing his services might not warrant, for instance, a workshop, and under those circumstances all he could do was to guard against the urgency of the need of one by having all his plant carefully inspected before shipment.

He might be so situated that he could command the services of an engineer's shop in some adjacent town, but even then it was not probable that he would find, even in a railway workshop, a lathe suitable for cutting threads on the joints of his drilling tools, or dealing with his casing.

In any estimate of his requirements he had to be guided by the finances of the company or syndicate employing him, coupled with the resources of the country which he might be able to command in the vicinity of his work; in a word, he must cut his coat according to his cloth.

Expenditure in workshops or spare parts and fishing tools should be looked upon as one would look upon the purchase of an insurance policy: they might not be essential to success; they might

never be required, but if not required it should be borne in mind that under certain circumstances by their supply they might have saved the work considerable loss by delay.

The author had given a list of very useful points, each of which should be touched on by anyone writing a report on the probable cost of working a property, and which should be enquired into on the spot, but it would take time to collect that information, more time indeed than was usually allowed for the drawing up of a report.

Two matters occurred to him which were not touched on in the paper. One was the form in which engineers should keep their accounts, which was an important matter, as it was calculated to assist in forming future estimates, and would enable him to see if economies were possible, and, if so, under what heads.

The present meeting was hardly the time to discuss the various heads and subheads of such an account, but he thought it was obvious that a recognised form should be adopted, so as to enable the directors to criticise and compare the expenditure with that incurred in other similar undertakings, and so that the engineer might be able to answer the criticisms.

The second point which did not appear to be alluded to was the form of log of drilling which should be kept, and he would suggest that to record the history of a borehole properly there should be two graphic logs, one showing the strata met with in drilling, and the casing inserted in the hole, and another on a "time base," the abscissæ affording the dates, and the ordinates the depth of the hole on those dates.

Those two mounted together afforded a complete history of the borehole, and one which could be apprehended at a glance, showing at what depths trouble might have occurred and, by the notes, the cause of that trouble. He would hand to the Secretary two blank logs* such as he had referred to, and also an abstract of account such as he had found useful, which latter could of course be adapted to meet special conditions.

HEADS AND SUBHEADS OF ACCOUNTS.

Abstract A.

Home (London) Expenses.

Abstract B.

Land.

B 1 Hire of Land.
2 Purchase of Land.

* The abstract of account is appended. The blank logs have been placed in the Library of the Institution.—Ed.

ABSTRACT C.

Management.

C	1		Manager's Salary and Assistants'.
	2		Agency.
	3		Secret Fund.
	4	a	Office Expenses. Salaries of Clerks.
	4	b	do. do. Wages of Servants.
	4	c	do. do. Stationery.
	4	d	do. do. Postages, Telegrams, Petties.
	4	e	do. do. Cables.
	5	–	Headquarters' Messing.
	6	–	House Accommodation. Headquarters' Staff.
	7	a	Travelling Expenses. Horse and Mule Hire.
	7	b	do. do. Stabling and Freight on Animals.
	7	c	do. do. Food for Mules and Horses.
	7	d	do. do. Repairs to Harness and Tents.
	7	e	do. do. Wages of Muleteers and Saices.
	7	f	do. do. Wages of Peons and Guides.
	7	g	do. do. Messing Expenses.
	7	h	do. do. by Rail, Steamer or Carriage.
	8	–	Medical Expenses.
	9	–	Watch and Ward. Guard.
	10	–	Loss by Exchange.

ABSTRACT D.

Drilling Expenses.

D	1	a	Drillers' Wages.
	1	b	do. do. Overtime.
	1	c	do. do. Allowances.
	1	d	do. Messing Expenses.
	2	a	Natives' Wages. On Rigs.
	2	b	do. do. Store Yard and Shops.
	3	–	Stores and Materials.
	4	a	Fuel. Wood.
	4	b	do. Coal.
	4	c	do. Oil.
	5	–	House Accommodation.
	6	–	Travelling Expenses.

ABSTRACT E.

Tools and Plant. Live Stock.

E	1	–	Drilling Machinery.
	2	–	House and Office Furniture.

E 3 – Camp Furniture and Tents.
4 a Live Stock. Mules.
4 b do. do. Horses.
4 c do. do. Cattle and Goats.
4 d do. do. Donkeys.

ABSTRACT F.
Compensation.

ABSTRACT G.
Freight and Customs Dues.

G 1 a Sea Freight on Plant and Machinery.
2 a Land Transport of Machinery, &c.
3 a Customs Dues on Food Stuffs.
3 b do. do. Stationery, Camp Kit, Furniture, &c.
4 a Hire of Store Rooms.
4 b Hire of Boats.

ABSTRACT H.
Roadmaking. Surveying. Prospecting.

H 1 – Hand Drilling.
2 – Earthwork. Excavation.
3 – Roadmaking.
4 – Surveying.
5 – Housing of Peons.

ABSTRACT I.
Launch Expenses.

I 1 a Fuel.
1 b Lubrication.
1 c Wages.
1 d General Stores.
2 – Repairs.
3 – Hire of Boat House.

Transport Suspense Account.

S.A.T. a Hire of Mules.
b Do. Bullocks.
c Freight on Mules.
d Do. Bullocks.
e Feed of Mules.
f Do. Bullocks.
g Cost of Harness.
h Repairs to Harness.

S.A.T. i Wages of Drivers.
k Repairs to Carts.
l Hire of Boats.
m Wages of Labourers Loading and Unloading.

S.A. Suspense Advances.

Mr. Arthur W. Eastlake said he had listened with a great deal of pleasure to the extremely valuable, but at the same time somewhat complicated, paper which had been read. It appeared to contain sufficient subject matter to form the basis of several papers. A large number of important subjects had been raised which he ventured to think would give even those most experienced in the petroleum industry food for thought.

He was quite in agreement with the author's remarks as to the tendency to cut down working capital, and he had known many instances where that had resulted in the failure successfully to develop promising oil lands, others than the original owners subsequently reaping the benefit. While he endorsed the views expressed as to the method of examining oil properties, and the setting forth of the various features to be mentioned in a report, which in recent years had been largely carried out, he desired to point out that it was purely a question of cost.

If the employers of petroleum technologists could be induced to adopt the policy indicated, the paper would have served a most useful purpose. Apart from that, he hoped the high aims advanced by the author would act as a guide to the members of the Institution in performing their professional duties.

Mr. C. B. Rosenplaenter said that reference was made in the paper to the usefulness of the Institution. Although the matter was not discussed in detail, he thought the experience of many of his colleagues had led them to the conclusion that the Institution could be of great service in supplying information which was not usually furnished to petroleum technologists when carrying out the investigation of a field.

In nine cases out of ten a representative of the vendor, or someone interested in the sale of the property, acted as the guide or the adviser to the man investigating the property, and it was naturally in his interest to give as little information as possible that would in any way deter the promoters or future investors from putting their money into the proposition. One of the first things he thought the Institution ought to do was to collect from every country in which petroleum technologists had to perform their

work the different laws that governed the working of petroleum fields and the rights of the owners and lessors of petroleum lands.

If those laws could be embodied in a book, so that either the technologist who had to make a report, or the investor who proposed to put money into the scheme, could have access to the information, it would be a very valuable piece of work. He believed that steps had already been taken with that object in view, and the sooner it was carried out the better it would be for all those engaged in the industry.

Mr. Ashley Carter said the author stated in his paper that prices or estimates for various classes of work were obtained from the foremen of the different workshops responsible for production, and reference was made to £100,000 contracts. A company dealing with the production of material to that extent had its estimating department and did not leave the furnishing of estimates to foremen, to the detriment of the production of work under their immediate charge. The estimating department was regarded by such a company as one of its most important and valuable.

The author also referred to the troubles of a boring master—the man of linguistic attainments—in relation to the casing that was supplied to him, it being stated that nearly every pipe had a slight variation in the thread, so that it was impossible to make up a column for the hole. With that he did not agree. He did not uphold what was supplied as anything approaching the perfection of engineering, but in his opinion when anybody was landed in such a difficulty, it was then the engineer showed his ability by finding some means out of the trouble.

An engineer must always be prepared to meet difficulties as they arose, and in the present instance he considered they could very easily have been overcome. He called attention to the fact that in the instance referred to there was nothing more serious than a slight variation of the thread.

Under those circumstances, where necessary, the couplings could have been forced on to the pipes. When he said "forced on"; he meant that one would start to screw them on, and probably strip the thread; if by that means they could not have been placed in position, they could have been filed on the inside with a half-round file, so that they could be passed over the pipe; the couplings could then have been placed on the pipe in their correct relative positions. He would have drilled through the couplings and through the pipe, would have tapped the holes, and would preferably have slightly countersunk them on the outside. He would

then have prepared studs which could be inserted into the holes, cut them off and riveted them over. That would have enabled the column to have been made up for the hole.

As an engineer he did not wish by any means to uphold that as good practice: he was simply bringing forward a way in which the difficulty could have been overcome by the adoption of rough and ready methods.

Dr. J. A. L. Henderson said that, as had already been stated, most of the members appreciated the fact that the paper was a counsel of perfection in regard to the matters with which it dealt, and it certainly would act as a model which those who were interested in the work as consulting engineers could very profitably follow.

The paper covered so much ground that it was obviously intended to deal with exploration companies in their widest sense, such as in new countries where few, if any, facilities were present for the carrying on of the work, and where little or no knowledge of the geological conditions existed.

It was clear that the author had taken, as he said, the maximum number of contingencies into consideration, very many of which did not apply to most of the known oilfields of the world. Very much of what the author said would commend itself to everyone who had studied the question, although Mr. Wells went into somewhat controversial ground at times. Personally he had not had time to go carefully enough through the paper to consider it in all its bearings, and therefore he could not make much useful criticism at the present moment, but he was sure that everyone would welcome the volume which the author had promised on the subject.

It would be a contribution to technology of great value, and would act as a useful supplement in furnishing details which it was impossible fully to set forth in the standard and classical work which the President had written.

He desired to say in regard to the carrying out of work on the field, and laying it out so as to meet the contingencies which continually arose in connection with companies, that, as one of the previous speakers had said, the time often arrived when the company must cut its coat according to its cloth. The counsel of perfection would not do. That time usually did arise once or twice in a company's existence before it was successful, and the engineer who was responsible for the work must be quite fearless in expressing his opinion and making certain that his directors and those responsible for the financial organisation of the company fully understood what they were doing. He quite agreed with all the author had said on that subject.

There was one point which he thought was very much overlooked, especially in this country, and that was the driller's vocation. A driller had a very responsible and well-paid position in many countries, and the success or failure of a well very often hung upon him. It would be very useful indeed if young engineers in this country gave their attention to that subject, and became practical drillers, so as eventually to become master drillers, because the more one saw of the drilling work in various parts of the world, the more one was appalled at the ignorance of the average driller, and the stubbornness of his refusal to carry out orders through lack of comprehension of what was required, and, in addition, his absolute refusal to keep such records as were required during the absence of his superiors.

Mr. Edmund Kimber agreed with the last speaker that the paper was a counsel of perfection. None of the members were perfect, not even the ablest engineer, the most learned judge, or the most learned philosopher, but that was no reason why they should not try to attain perfection. He had known many disastrous episodes in the oil industry throughout the world.

The reason of the ignorance of the engineers alluded to by the last speaker was that the oil industry was so vast and great that it had outgrown the intelligence of the engineers, and the indications in the different oilfields of the world were so various that even the most learned men were often mistaken.

They made reports upon *prima facie* evidence which subsequent experience showed to be almost entirely unfounded. Oozings of oil were found on the surface, and they came to the conclusion that oil must be there. He had no doubt it was, but the question was whether it was there in payable quantities. He had known several companies which had been started upon such indications, and thousands of pounds had been lost, simply because it was presumed that as there was a superficial indication of oil on the surface there must be a vast quantity of oil beneath.

That did not at all follow. Those indications existed in various parts of the world, whereas in other parts there were no indications at all, except the nature of the rock beneath which were found vast quantities of oil.

How was it possible to provide against those contingencies? It was impossible; it was a speculation, and it was for that reason that as many guides as possible were required like their learned President and the author. He should be very sorry to say, however, that even their learned President and the author were men of perfection. They were not omniscient; they could not see

below the earth. After all, there was a good deal of guesswork about it. No one could really tell what the earth contained until he began to bore.

It was within the experience of the President and the author that hundreds of thousands of pounds had been lost by gentlemen who had entered into oil concerns simply upon surface indications.

In Venezuela, California, New Zealand, Australia, Egypt, Pennsylvania, and Canada millions of money had been lost during the last thirty or forty years in oil undertakings. No one said that there had been intentional fraud, although of course there had been some frauds, and there were some frauds going on at the present time. It was impossible, however, to make everyone honest all of a sudden. He rejoiced to find that in the present assembly at any rate there was the dawn of some signs of real commonsense.

Mr. John Wells, in reply, desired in the first place to thank the members for the kind reception accorded to his efforts. It was not his wish to take an impossibly high standard, but, at the same time, he believed that for the younger members of the profession a certain amount of idealism was an advantage; there should always be a rung of the ladder ahead, and it was better to look towards that than to the rung below, as it was always a help in their professional career. With regard to the remarks made by Mr. Reynolds, he had not dealt in detail with the points to which that gentleman referred, but it would be noticed that under Clause (12) he had mentioned the necessity for the provision of methods of recording. The question of the recording of boreholes, etc., was one which required very considerably more thought and study than had hitherto been given to it, and if a general scheme could be evolved which would be suitable for all cases he had no doubt it would be of great advantage. When Mr. Carter was giving his method of overcoming the difficulty connected with the casing, he pictured in his mind that gentleman or any other engineer filing a 10-inch pipe in a hot sun. He had had to file the threads on a 6½-inch pipe in order to make a few pipes in a column fit; it was a long and tedious business even for a few joints, but seriously to consider applying this method to long columns of casing was beyond the capacity of most men.

The President said that the members had by their applause anticipated what he was about to do, namely, to propose a very hearty vote of thanks to the author for his valuable paper.

The resolution of thanks was carried with acclamation.

The following paper was then read :—

Oils from Peat.

By Dr. F. Mollwo Perkin, F.I.C., F.C.S., *Member*.

Owing to the vast extent of the peat bogs in various parts of the world, and the uselessness of the land for agriculture, the possibility of the utilization of the peat has always interested a large number of investigators. The problem, however, is one of very great difficulty. In the first place the peat is usually covered with a useless overburden, some two feet deep, of grass, moss and heather. This has to be removed, and is of very little value, except for litter. Secondly, the peat holds very large quantities of moisture, averaging from 80 % to 90 %. That is to say, for every 100 tons of theoretically dry peat which has to be worked up, 80 to 90 tons of water have to be eliminated. By careful drainage of the bogs the water content may be reduced, but not to any great amount —at the most from 5 % to 8 %.

Cut peat, when stacked, loses a large amount of moisture fairly rapidly, and in the course of a few weeks, given dry weather conditions, the moisture may be reduced to about 25 %. In this state it is used as a fuel by the peasants in many countries. The rate of drying naturally depends on the prevailing atmospheric conditions. Thus, in a wet summer very much less peat could be cut and dried than in a dry one. Generally speaking, it is feasible to cut peat during only six to seven months in the year.

As a fuel, peat has not the same value as coal, and has the disadvantage of giving a very soft dust, which blows about with the least draught. On the other hand, it gives out an intense heat, and raises steam in a boiler more rapidly than most other fuels. In Norway and Sweden peat, ground to a fine powder, has been successfully employed on locomotives, the method being to blow it into the combustion chamber. The following table, published by Professor Klason of Stockholm, gives the approximate analysis and calorific value of peat containing about 25 % water, and some other fuels.

Composition.	Wood.	Peat.	Lignite.	Swedish Coal.	British Steam Coal.
Carbon	52·0	58·0	66·0	78·0	81·0
Hydrogen	6·2	5·7	4·6	5·1	5·2
Oxygen	41·7	35·0	28·0	14·8	11·5
Sulphur	—	—	—	0·8	1·0
Nitrogen	0·1	1·2	1·0	1·3	1·3
Moisture	20·0	22·0	25·0	18·5	7·6
Calories	4900·0	5700·0	6000·0	7500·0	8000·0

The content of ash varies very much. If it is less than 5 % on the perfectly dry sample, it is low, whereas if it is above 8 %, it is high. The ash content is indeed of great importance, because most processes for obtaining oil depend upon the dry distillation of the peat, and the resulting residue is charcoal. Charcoal containing a large quantity of ash is of very little value for metallurgical purposes. Generally speaking, about 30 to 33 tons of charcoal are obtained from 100 tons of peat containing about 15 to 17 % of moisture.

In the table just given, the sulphur content of the peat is not stated, but I have found it vary considerably. When there is any considerable quantity of sulphur present, the oil produced is strongly contaminated with organic sulphur compounds and sulphuretted hydrogen, the bulk of which, however, is easily removed by treatment with alkali and acid.

The nitrogen content also varies considerably, some Scotch and Irish peats having over 2 % of nitrogen. The amount of nitrogen is a very important factor, because, if it is high, a large yield of the valuable by-product, sulphate of ammonia, is obtained.

When peat is distilled, a thick semi-solid black tar containing considerable quantities of solid paraffin wax is obtained, together with an aqueous distillate containing ammonia, acetic acid, acetone and methyl alcohol. The latter two substances, however, are difficult to condense; therefore the gases given off should be carefully scrubbed and well cooled. Generally speaking, from one

ton of peat which has been briquetted and contains about 20 % of moisture, 5000 to 6000 cub. ft. of gas are obtained, having a calorific value of about 130 B.Th.U. This gas can be burnt under the retorts, and is just about sufficient to distil the peat without the application of other sources of heat. Where, however, the moisture content is higher, a further supply of heat is necessary to carbonise the peat and to drive off the volatile matter. Much higher yields of gas are obtained when peat is carbonised in a producer.

I have superintended the carbonisation of peat containing 70 % of moisture when, owing to the amount of water which had to be evaporated, it was a matter of great difficulty to keep the retorts sufficiently hot, although large quantities of extra producer gas were burnt under them.

The thick oily tar cannot be treated for separation of phenols and bases until it has first been subjected to distillation. Good results can be obtained by taking off fractions up to 160° C., and from 160° C. to 270° C. with ordinary heating. The last fraction must be taken over with super-heated steam, as otherwise large quantities of retort carbon are produced. It is difficult to obtain a good separation of the tar from the water, because the sp. gr. of the tar is almost the same as that of water.

All the fractions have a strong smell of burnt peat. The lowest fraction can be readily washed with alkali and strong acid without emulsification, but the higher fractions are more difficult to deal with, and at times emulsify very badly. When this is the case, it is best to wash with warm dilute alkali and water. Even then, although the bulk of the water separates out, it takes a considerable time for the oil to clear.

The yield of oil from a briquetted peat obtained from Yorkshire, and having the following analysis, was 88 gal. per ton.

Moisture	18·28 %
Volatile Matter	52·21 %
Fixed Carbon	16·72 %
Ash	2·79 %

This oil was fractionated with direct heat, when the following fractions were obtained:—

Below 150° C.....	1·35 %	0·867 sp. gr.
„ 250° C.....	29·90 %	0·953 „ „
Above 250° C.....	50·00 %	0·941 „ „

A residue of hard pitch containing some carbon was left behind. The highest fraction solidified, and contained about 6 % of hard paraffin wax. By steam distilling, slightly better yields of the

various oils were obtained. All the oils contained small quantities of bases, and the middle fraction considerable quantities of phenols.

On removing the bases and phenols, and treating with strong sulphuric acid, the unpleasant burnt odour is removed from the oils, and pleasant-smelling products result, the specific gravity also being improved, as is shown by the two lower fractions.

Below 160° C. ..... 0·801 sp. gr.
„ 260° C. ..... 0·821 „ „

It should be mentioned that probably a larger yield of oil could have been obtained, had the peat been left longer in the retort, or the retort heated to a higher temperature. This is shown by an analysis of the coke, which was as follows :—

Volatile Matter..... 11·82 %
Fixed Carbons ..... 79·71 %
Ash..... 8·47 %

The temperature employed was 550° C.

Another peat, which contained 69 % of moisture, gave slightly different yields of the various fractions.

Below 150° C..... 3·4 %
„ 230° C.....18·3 %
Above 230° C.....57·2 %

The results, however, are not quite comparable, because there is a slight difference in the range of temperatures. Another difference is that a horizontal retort was used in the first case, and a vertical retort in the other case. In both instances, over one ton of peat was carbonised. Had more efficient scrubbers been used, the yield of the lowest fraction would certainly have been slightly higher.

As to the nature of the oils, they appear to be largely paraffinoid.

The yield of sulphate of ammonia in the second case was 11 lbs. per ton. In the first case about 22 lbs.

The carbon left behind is of good calorific value, and, if the peat has first been well briquetted, should be sufficiently hard to stand the necessary overburden in metallurgical operations ; or it may be briquetted separately after having been carbonised.

The calorific value of a Scotch peat, containing 15·4 % moisture, and charcoal was as follows :—

	Peat.	Charcoal.
British thermal units	8558	13,680

The question naturally arises, can oil and other by-products be profitably extracted from peat ?

I believe they can, but there are many difficulties in the way,

which, however, are to my mind not insurmountable. The initial difficulty, and the one upon which most peat propositions have turned out failures, is to remove the large amount of water invariably held by peat. It must be borne in mind that peat, as dug, contains from 80 % to 90 % of moisture, that is to say, for every 100 tons of peat removed from a bog 80 to 90 tons of water are present. Now in most processes for the utilisation of peat it is essential to remove the bulk of this water. Peat briquettes, containing more than 20 % of moisture, do not give a sufficiently hard residue of coke. True, if the peat is not briquetted, but is partially dried before being placed in the retorts, and the charcoal afterwards briquetted—as by the process of Mr. J. W. Leadbeater—it may contain up to 40 % of moisture. Here again, however, the question of economy in fuel must be taken into account. One pound of water, under any given conditions, always requires the same quantity of heat to convert it into steam, consequently double the amount of water requires double the amount of fuel. When peat is briquetted and dried so as to contain from 18 to 20 % of water, then on being charred each ton produces from 5000 to 6000 cub. ft. of gas, having an average calorific value of 130 B.Th.U. The process once started, the gas produced by the carbonisation, and which is burnt round the retorts, is more than sufficient to continue the carbonisation. There is thus a certain amount of residual gas which can be employed for other purposes. When, however, the amount of moisture exceeds 20 % the quantity of gas produced is not sufficient completely to carbonise the peat. As a consequence extra fuel has to be employed. Further, as already mentioned, the charcoal briquettes suffer in point of hardness.

It should be mentioned that on the plant of the Tarless Fuel Company, which is worked under a considerable vacuum, peat may be carbonised satisfactorily, and the by-products collected with a lower fuel consumption than when the distillation is carried out at atmospheric pressure. In all cases, however, the question of hardness of the carbon produced depends upon the amount of water present. The Del Monte plant also gives good results.

It has not yet been explained how the water is to be eliminated in the first place. If peat freshly dug from the bog is subjected to hydraulic pressure, only from 5 % to 10 % of the moisture is driven out. If, however, the fibres are broken or disrupted, then, on being pressed, a very much larger proportion of the water can be forced out, and a comparatively dry cake containing, say, 30 % to 35 % of moisture, is obtained. It was Eckenberg who first showe l

that if peat was heated with steam under pressure the fibre was burst, and that the water could be forced out by pressure. This process has now been much developed by Wet Carbonisation, Limited, who are working it on a large scale in Dumfriesshire.

A method which has been very much employed is to grind or pulp the peat after it has been dug, and without previous drying. The object of grinding the peat is to break up the cells. After having been ground, the peat is briquetted, and dried either by atmospheric exposure or by warm air. In a carbonising plant, the hot flue gases are used to dry the briquettes, and any residual gas which is left over after heating the retorts can be burnt, and the heat thus produced also employed. If, however, the briquettes are dried too rapidly, they warp and crack, and as a consequence the charcoal produced on carbonisation is not sufficiently hard and homogeneous to stand a heavy overburden when used for metallurgical purposes.

My own experience is that peat briquettes should first be partially air-dried before artificial heating is employed. Electrical processes have also been suggested for disintegrating the fibre.

Owing to the large volume of raw peat required to produce a given quantity of dry peat, the labour item requires careful consideration. If the dried peat costs more than 5*s*. to 6*s*. per ton, I very much doubt whether a peat proposition to obtain oil and carbon will be a paying one. I believe, however, that with a carefully thought-out plan the actual cost should not exceed 4*s*. 6*d*. per ton. A very large number of macerating plants have been patented both in this country and abroad, but it hardly comes within the scope of this paper to describe them. To work up peat on a small scale will not as a rule pay, because of the charge for labour. The following is the cost got out for me by Mr. H. Shaw Dunn, of Glasgow, for dealing with 5 tons of dry peat per day.

SCHEME TO PRODUCE 5 TONS OF DRY PEAT PER DAY FOR 6 MONTHS.

The experimental station will be erected at the edge of the bog, and, to save capital expenditure, the digging and drying processes will be carried out by hand labour.

Digging and drying will be done six days a week, but the producers must be worked seven days a week.

One man will cut four chains of peat every week (a chain is 66 ft. × 4 ft. × 4 ft. and yields 29 tons of wet peat), $29 \times 4 = 116$ tons per week. The producer requires $50 \times 7 = 350$ tons per week.

$\frac{350}{116} = 3$ men, say 4 men.

To collect the cut peat, and deliver it to the elevator feeding the maceration hopper, eight boys with trucks will be required.

To take charge of the macerator and press for making peat bricks, one man will be enough, and to keep the press clear and take the bricks to the drying ground and sheds, ten boys with the aid of trucks ought to suffice.

One additional man will be required to superintend operations inside the drying sheds, or on the drying grounds.

Summary of labour required to dig and air-dry 350 *tons wet peat per week:—*

		Per week. £	*s.*	*d.*
Digging.....	4 men at 32*s.*	6	8	0
Collecting.....	8 boys „ 12*s.*	4	16	0
Macerating	1 man „ 30*s.*	1	10	0
Stacking and Drying....	1 „ „ 26*s.*	1	6	0
„ „ „	10 boys „ 12*s.*	6	0	0
		£20	0	0

26 weeks at 20*l.* .....520*l.* 0*s.* 0*d.*

Labour of final drying and handling.—Exposure to the atmosphere for 14 days in fairly dry weather ought to dry the peat to 50 % moisture.

If the weather was fine, the peats could be dried on the ground where they were dug; if not, they must be taken to the drying sheds. Probably a combination of the two methods will be necessary. After being dried down to about 50 % the peats will be put into a shed fitted with shelves, through which a strong current of hot air is constantly passing. To fill and empty the hot-air drying sheds an additional staff of men will be necessary.

50 tons of wet peat = 66 cub. yd. (15 cwt. per yd.). Each fresh-dug peat sod 9 in. × 3 in. × 3 in. contains 81 cub. in. of peat, $66 \times 27 \times 1728 = 3{,}079{,}296$ cub. in., $\frac{3{,}079{,}296}{81} = 38{,}016$ sods in 50 tons.

The racks in the air-drying sheds would require to be 5 ft. 3 in. long by 21 in., and each rack would carry 192 peats, $\frac{38{,}016}{192} = 200$ racks for one day's work. $200 \times 14 = 2800$ racks required for 14

days' work. Put the racks in sheds, 12 to the width of the shed, $\frac{2800}{12}$ = 234 sections each 5 ft. 3 in. long = 1250 ft. of sheds.

From these air-drying sheds, the peat must be conveyed to the final drying sheds, built of brickwork with substantial roof, fitted internally with racks and hot-air distribution flues. Air-dried peat loses very little of its original bulk at 50 % water. The hot-air sheds will be fitted with racks from floor to roof, 27 racks in each section 5 ft. 6 in. long. Each section will hold $27 \times 192 = 5184$ bricks $\frac{38{,}016}{5184}$ = 8 sections = to a shed 44 ft. long.

On the assumption that the peats will be dried in 24 hours, and that each shed can be filled and emptied in 24 hours, four sheds will be required to keep the producers going continually.

One man and 10 boys will be required to fill and empty these sheds.

1 man at 26*s.*	..	..	1*l.* 6*s.*	0*d.* per week.
10 boys „ 12*s.*	..	..	6*l.* 0*s.*	0*d.* „ „
26 weeks at 7*l.* 6*s.*	0*d.* per week =		189*l.* 16*s.*	0*d.*

One foreman will supervise the whole of the peat digging and drying processes, and he will ultimately be able to let out the various parts of the process on piecework. His wages will be 30*s.* per week = 39*l.* for six months.

A boiler and engine will be required, and a second-hand set will cost about 120*l.* The boiler will consume 10 cwt. of coal per day equal to 4*s.* 188 days at 4*s.* = 38*l.*

An estimate will be required for the elevator and press, but they ought not to cost more than 300*l.*

1200 ft. of air-drying sheds, 16 ft. wide and 6 ft. high at the eaves, will be required, and these fitted with racks will cost, if made of rough boards, about 20*s.* per lineal, 1250*l.*

Four drying sheds, built in a block with iron roofs fitted with racks, flues, exhaust pipes and fan, will cost roughly 1000*l.*

To sum up, the costs are as follows :—

	£ s. d.	£ s. d.
Labour—		
Digging, macerating, and air drying.....	520 0 0	
Drying by heating	189 16 0	
Foreman	39 0 0	
		748 16 0
Carried forward		£748 16 0

	£ s. d.	£ s. d.
Brought forward		748 16 0
Material—		
Boiler and engine	120 0 0	
Fuel, oil, etc.	100 0 0	
Macerator and elevator	300 0 0	
Open sheds	1,250 0 0	
Heating sheds	1,000 0 0	
Rails, trucks, etc.	200 0 0	
Tools.....	100 0 0	
		3,070 0 0
TOTAL		£3,818 16 0
Contingencies 10 %		381 4 0
		£4,200 0 0

It is expected that sufficient gas will be available to generate enough heat to reduce the water contents of the peat from 50 % to 20 %, but I am very doubtful about this. It is also questionable if the peat will give up its moisture in the hot-drying sheds in 24 hours. This is the weak spot in the scheme.

The above estimates were for a small experimental plant. In dealing with a large plant, the peat would be grubbed out mechanically and conveyed to the macerator, also by mechanical means. There would thus be a very great saving in labour. The great space required for the peat briquettes while they are being dried, will always, however, be a difficult problem. This can be very much reduced if the fibre of the peat is disintegrated, either by heat or electrical or other process, so that the water can to a great extent be pressed out hydraulically. I believe that by a combination of the processes suggested, a workable and paying scheme can be devised.

DISCUSSION.

The President said that the paper had been of very considerable interest to him because, if he might be pardoned for intruding a personal note into his remarks, it recalled the days of his youth. Between forty and fifty years ago, when he was a student in the laboratories of the Pharmaceutical Society, where at that time his father was Professor of Chemistry, Dr. Benjamin H. Paul, who was also connected with the Society, was carrying out an investigation

of the question as to whether it was possible commercially to manufacture oils and ammonia from the peat bogs of this country.

He believed that the two difficulties which he experienced were those which Dr. Perkin had alluded to as in his opinion in course of being overcome, namely, the drying of the peat and the character of the carbon resulting from the retorting of the material. If it were true that those difficulties had been overcome, he agreed with the author that there was every hope, having regard to the quantity and character of the products which could be obtained, that the industry of utilising peat as a source of mineral oils and ammonia was capable of being brought to successful commercial fruition, and he was quite sure that in the hands of the author there was a very good prospect that everything possible in that direction would be accomplished.

Mr. Buckle said that the paper had interested him very greatly, as he had done a lot of work on the subject, the results he had obtained agreeing substantially with those obtained by the author. He had also experienced the same difficulty that Dr. Perkin mentioned in the removal of the very large amount of water from the peat, but that trouble had been overcome in large measure. There was a plant in operation in London, which had been working for about twelve months, and which produced the peat in such a state that it was available for carbonisation immediately, and he would be very pleased to show that plant to the author.

With regard to the question of the carbonisation of peat, he found, as a rule, that in the distillation of peat a large amount of water distilled over, and it was very difficult to separate the tar from the water. As a matter of fact, it was practically impossible to separate the two. The gravity of the tar and the water was nearly identical, and it was practically impossible to separate them mechanically.

Some years ago he carried out some work in the briquetting of metallurgical coke, and curiously enough obtained pretty much the same results as those obtained by the author. In the first coking he obtained friable coke, and he found that if that friable coke was briquetted with about 33 % of peat-tar free from water, and then re-coked, a very substantial metallurgical coke was produced. He agreed with the author that something could be done in that way.

There was one other point he desired to mention. In the distillation of peat the amount of tar produced was comparatively small compared with the amount of other products; he thought about 6 % of tar was all that was produced in ordinary circumstances. A very great amount of gas and sulphate of ammonia was also

produced. In certain circumstances it was more advantageous to utilise peat in other ways than by carbonising, such, for instance, as a process of moist combustion as in the Mond producer plant.

In some figures given by the author of yields of sulphate of ammonia obtained from peats, in one instance 11 lbs. per ton were obtained, and in another case 22 lbs. per ton. Personally, he knew of a producer plant which had been worked for some time, and which had given over 200 lbs. of sulphate of ammonia per ton of peat in a test conducted under the supervision of a colleague of Sir Boverton Redwood, Mr. Gordon Salamon.

He desired to point out that in some cases it would be more advantageous not to coke peat, because the sulphate of ammonia was the most valuable by-product, and, in addition, the amount of gas produced was considerably more in the moist combustion plant than in the carbonising plant.

He had obtained higher figures than those mentioned by the author, of about 6,000 cub. ft. per ton of peat for carbonised peat, and from peat treated in the moist combustion plant as much as from 85,000 to 90,000 cub. ft. were obtained. Of course, no coke was obtained. In that case the gas was used for power purposes.

Dr. Ormandy said it seemed to be a peculiar characteristic of the English race that, in dealing with what ought to be a scientific subject, they started off with the assumption that the work which had been done in their own country was all the work that had been carried out on the particular subject.

The literature of the attempts to dry peat, the literature of the character of the various types of peat, would fill enough volumes practically to go round the room in which the meeting was being held. An enormous amount of money had been spent on endeavours which had been planned, not by wildly speculative people, but by the very highest skilled chemical and engineering brains in the world, which had been devoted to the subject for something like the past fifty years.

He had himself in his possession at the moment a history of the spending of £270,000, the greater portion of which was spent on machinery specially designed, one type of press after another, by the firm of Krupp, in their endeavours to deal with the enormous deposits of peat which were found in the kingdom of Germany.

The result of all the work, if it was properly construed, led one to the conclusion that the majority of peats were in such a physical condition that it was an utter impossibility to reduce the water to such a limit by the mere action of pressure, without any previous treatment, as would leave a product which it was worth while

dealing with as a commercial proposition, either by use in a Mond plant, where it was possible to have a considerable amount of water—where, in fact, it was even advantageous—or by ordinary distillation. He had seen in this country a process which offered very considerable prospects of success when dealing with certain specified types of peat.

When speaking of peat one was as liable to be led astray as when speaking of coal as a generic term. There were bituminous coals and cannel coals, and their behaviour under distillation was as different as it could possibly be, but in the case of peat it was the physical structure which was different. There were the fibrous peats, the modern peats, which lent themselves fairly well to treatment by pressure.

On the other hand, some of the peats were absolutely colloidal, and in that case unless there was a preliminary treatment, or other means than pressure adopted, there was not the slightest hope of dealing with them by any physical means.

Even granted that dry peat was obtained, the question of the nature of the distillate was obviously absolutely dependent upon the temperature employed, and he was able to say from hundreds and hundreds of experiments which had already been carried out that the nature of the distillate was not only dependent on the temperature employed, but it also depended on whether the peat which had been distilled was of that particular colloidal type which consisted very largely of pentoses, or whether it was of a fibrous type, where there was a considerable proportion of cellulose bodies.

The whole subject of the treatment of peat seemed to him worthy of very much more consideration than it had received from the scientific side in this country, and particularly the attempts to make use of the laws of science which had been very little investigated in this country; he meant the utilisation of pressure produced by electro-osmotic means.

He had seen a sample of the most colloidal peat that could possibly be obtained, containing 90 per cent. of water, put through a grinding machine and reduced to a state in which it appeared more like treacle than anything else, which, after certain non-costly preliminary treatment, gave a product in the course of 20 minutes which resembled a cocoanut shell. It was so hard that it crackled underfoot, and that product, containing 28 to 32 per cent. of water, which could be dealt with by any Mond plant, had been known to give as much as 180 to 200 lbs. of sulphate of ammonia to the ton of dry contents. On the other hand, if it was distilled at comparatively low temperatures, and then raised to a high

temperature at the end, it gave a coke which was almost ideal for metallurgical purposes, very low in sulphur, phosphorus and ash, and consequently exceedingly useful for steel-smelting purposes, where sulphur was so objectionable, and particularly useful in a finely divided form in conjunction with other articles, for the case-hardening of steel.

At the present late hour it was utterly impossible to deal with the subject as it might be dealt with, but he desired to point out that the results which had been put before the members in the paper would be very much easier for comparison if they were all reduced to a basis of a certain water content.

It was somewhat difficult, when hearing a paper read, to compare yields based in the one case on 60 per cent. of water and in another case on 40 per cent., and so on, and for the sake of comparison it would save a great deal of trouble if the results were reduced to some standard basis of moisture.

He believed that on the Continent it was customary to accept 25 per cent. as being the lowest amount of moisture to which it was possible, under average weather conditions, to reduce peat without artificial drying.

On the other hand, he was astonished to hear that the metallurgical value of the gas produced from the distillation of peat, presumably fairly dry peat, was 130 B.Th.U.

He recently saw some analyses made by one of the gas analysts of a London gas company, showing a gas having over 500 B.Th.U. produced from the distillation of peat containing 25 per cent. of water. He was open to admit that it was quite possible that adequate means were not taken for washing the gas from the volatile liquids which might have been carried over. Sufficient oil scrubbers were not attached, but the difference in the figures was so great as to require some explanation.

Another point on which he would be very thankful for any information was in regard to the percentage of methyl alcohol, which was produced by dealing with peat, and at what temperature or temperatures or in the presence of what amount of water the percentage of methyl alcohol was highest. The subject was of particular importance at the present juncture, in view of the necessity of obtaining supplies of methyl alcohol, and the way in which its price was rising.

In the effort which was now being made to make this country as self-contained as possible, it was desirable to bear in mind the treatment of peat as a source of methyl alcohol and acetic acid, which were at the present time almost at famine prices, owing to

the supply being in hands which were at present out of their control, but which were, he hoped, gradually getting within it.

Mr. S. F. Stackard said he did not desire to refer to the technical part of the paper, but the last speaker had put a thought into his head which he hoped the meeting would forgive him for alluding to in the briefest possible space. The last speaker had alluded to the question of certain chemical industries which had hitherto been in the hands of very strong competitors of this country, but which it was hoped would soon come back to this country.

He thought the members would be interested to know that the aniline industry, which had unfortunately been captured by Germany, was originally discovered in this country by Dr. Perkin's father. He ventured on behalf of the members to express the hope that the time was not very far distant when the work of Sir William Perkin might result in increasing prosperity to the inhabitants of this country.

Dr. Mollwo Perkin, in reply, said that he had not referred in his paper to Mr. Buckle's process, but he would be very pleased to accept the invitation that had been given to him to inspect the plant. He happened to know something about it. The question of whether the peat should be burned in a producer or not was one of great interest. Very considerable experiments in that direction had been carried out in Canada and also by the Mond Company.

The question of whether 100 lbs. or 200 lbs. of sulphate of ammonia were obtained in a producer depended entirely on the amount of nitrogen in the peat, and also upon the form in which the nitrogen was present.

In the particular cases he gave in the paper the coking was done at low temperature, not above 550° C., and under those conditions large quantities of ammonia were not obtained. From the amount of the nitrogen left in the coke it was quite easy to see why that was the case.

The peat, partially dried, might be passed directly through a producer, or it might be first carbonised, and the resulting coke put through the producer. The particular form of the coke would not matter much if it was to be used for producer purposes, and it might contain much more ash than if it was to be employed for metallurgical operations.

In the distillations referred to in the paper, neither the oil scrubbers nor the water scrubbers were as satisfactory as might have been wished.

He had obtained much higher yields of sulphate of ammonia in

some cases. He quite agreed with Dr. Ormandy that the literature on peat was very great, and that a very large amount of work had been done on the subject in Germany, Russia, Sweden, and Canada. The Canadians found that the Krupp producers were not so good as the producers modified by themselves. He could point out more than one case in which over £200,000 had been lost in experimenting on peat.

The tendency in regard to peat had been too much to get hold of an idea, and then to rush up a big plant, spending an enormous amount of money upon it, instead of installing a small experimental plant to start with. He thought Dr. Ormandy quite agreed with him on that point. He had never seen the osmotic process worked, but he saw no reason why it should not be satisfactory, if the difficulty connected with the expenses could be overcome. He doubted if these were so low as was generally claimed. He did not quite know what electrolyte would be employed.

Some work had been done recently in respect of the separation of clays which gave beautiful results, but it did not seem to go very far; the process, he believed, had been abandoned without ever having been worked on a large scale. He understood that the clay lost its plasticity. The osmotic process might get rid of a portion of the ash, and also of some of the sulphur and phosphorus.

With reference to the water content, he simply gave the different contents to show the difficulties of dealing with peat. It was necessary for experimenters to make up their minds, in working a process, whether they intended to spend a lot of energy in fuel by working with peat containing a large amount of water or not.

The methyl alcohol, acetone and acetic acid varied very much with the amount of water. He had never obtained more than about 2 cwt. of methyl alcohol per 100 tons of peat carbonised, the peat containing 20 per cent. of moisture. With higher proportions of water it was very difficult to separate the methyl alcohol.

He sincerely hoped, in reply to the remarks of the last speaker, that this country would be able to do more work in reference to aniline dyes in the future; in fact, he knew that more was already being done.

The President said he was sure it was the wish of the members to give a hearty vote of thanks to Dr. Perkin for his paper and to express the hope that he would continue his investigations.

The resolution of thanks was carried with acclamation, and the meeting terminated.

NOTE CONTRIBUTED BY

W. H. Dalton, F.G.S., *Member*, late of H. M. Geological Survey,

On the Continuation in Depth of the Angles of Dip Visible at the Surface.

There appears to be a fixed idea prevalent amongst drillers that in new fields, or in the deep-seated portions of such as have been explored to but comparatively shallow depth, high dips near the surface usually, if not invariably, decrease in amount with depth attained.

This opinion might be regarded as merely an indirect expression of hope, desire being proverbially generative of creed, or as optimistic encouragement of others to persevere under difficulties arising from high dip of strata, or attributed to that cause. But if maintained as a permanent belief, some other basis must exist for its general acceptance.

It can scarcely, however, be derived from inspection of cores obtained by crown-drilling processes, as that system is far less extensively adopted than others affording no cores by which the dip of deep-seated strata can be directly determined. Core-drilling is necessarily restricted to somewhat compact rocks, of greater antiquity, as a rule, than the less coherent newer deposits, and consequently having been more liable to disturbing action. Any large collection of cores is likely, therefore, to exhibit many cases of high angle of dip, and no such general impression could be derived therefrom as that under consideration.

If, on the other hand, the belief is based on diminution of tendency to cave, it is at least founded on more extended personal experience, although still not an irrefragable deduction from the facts. Deeper-seated beds may justly be supposed, *à priori*, to be more compact, and therefore less liable to cave, despite the increased compression under which they exist. But the pressure is unlikely to select bedding-surfaces in preference to joint-planes, in respect of such small liberty of movement as the uncased part of a borehole may offer, and even where the bedding-planes dip steeply, detachment implies closely approximating joints. Still, as a general rule, caving is more common in soft and incoherent beds, where neither joints nor bedding-planes have much value as determinants of the fall of cavings into boreholes. Consequently, diminution of the tendency to cave may more safely be attributed to increased coherence of the strata than to reduction of the angle of dip.

Whether this creed of many drillers is based upon observation, or is merely legendary, there is some reason to regard it as true in not a few instances.

In the profile of any contorted region, taken across the general strike, the surface dips must be supposed to remain constant in angle downwards, not vertically, but on lines drawn at right angles to those representing the dip, and successive horizons must lie approximately parallel to each other, at right angles to each such normal. It will then be seen that with curvatures that are concave upwards, the dips on any vertical line, representing a borehole, will decrease with the depth, whilst in curvatures that are convex upwards they will increase.

This holds good for such depth only as each curve is free from interference of other flexures. When two normals meet, it is evident that neither will continue to be the normal for lower beds, its function being taken by one bisecting the angle at which the two meet.

Carrying out this principle, it will be found that the most complex series of flexures becomes simple, and finally dies downwards into horizontality. If a similar course be followed upwards, reconstructing the portion of the mass removed by denudation, a like disappearance of flexure takes place, so that outside of a zone of some four or five miles in thickness all curvature vanishes.

This at first sight points to the absurd conclusion that flexure has been restricted to the zone destined eventually to be exposed for study in the present era. But we find on further analysis of the data that such contorted strata have constituted the surface of land or sea-bed at vastly remote geological periods, as well as in the intervening and present epochs, and therefore, if any reliance can be placed on the principle of construction set forth, it follows that all flexure is more or less superficial, the movement, under lateral pressure, which has been rendered possible by the reduction of the weight of overlying rock. The depth at which such movement may take place depends upon a variety of independent conditions, the rigidity, both of the matter under compression and of that above it, being among the most important factors. There is evidence, for instance, of pressure existing in molten rock (the granite of Shap, Westmoreland), three or four times that of the weight of the rocks overlying it at the time of consolidation, demonstrating the lateral coherence of the cover to have been adequate, not only to support its own weight, but to resist an uplifting force of far greater amount.*

* *Quart. Journ. Geol. Soc.*, vol. xxxi, p. 582, &c. (1875).

The relative ductility of various beds in the same series will be a factor of importance in the resulting deformation, the less coherent giving way to strain the more readily. As the weakest point gauges the strength of the whole, the initiation of flexure may be determined by extremely trivial details, such as irregularities of the original sea-floor, soft deposits following upon rock already compact, thinning and thickening of individual beds into a series of irregular wedges, accumulations of pebbles, whose rounded surfaces tend to deflect pressure, or even the ovoid form of concretions of ferruginous, calcareous, gypseous or siliceous nature. When curvature has once commenced, increased compression or decreased load will accentuate and, generally, complicate the disturbance.

That some such initial element of weakness is essential to movement is well shown by the gneiss of Massachusetts, which exists under great lateral pressure at the surface, so that blocks extracted in quarrying immediately expand, and the adjacent masses take advantage of the space vacated, often with explosive violence. A mass of 10,000 tons has been seen to travel three-quarters of an inch from this cause, and the movement is more pronounced in the deeper excavations.* In this case, doubtless, a great part of the original pressure has been already relieved by the action of meteorological changes, or the effects would be more perceptible, but centuries of natural erosion may effect less than a very brief exercise of human energy.

The removal of great thicknesses of rock is of course a very gradual process, and far from uniform, although local differences may bear but a slight relation to the whole depth concerned. It is this extremely slow change that permits "rigid" beds, which a sudden movement under pressure would fracture, to assume unbroken curvatures, increasing with further relaxation of the counterbalancing weight.

In Col. MacMahon's description of the geology of Simla,† it is suggested, in explanation of the general occurrence of vertical or highly-contorted beds in the valley-bottoms, whilst the slopes exhibit lower and lower dips, and the top beds are often quite flat, that some of the contortion has occurred since the erosion of the valleys, the strata beneath the maximum weight being crushed, with diminishing effect at successively higher levels. This hardly tenable hypothesis differs entirely from that now

* *Proc. Amer. Assoc.*, vol. xxii B, pp. 156–163: *Proc. Boston Nat.-Hist. Soc.*, vol. xvi, pp. 41, 42 (1874).

† *Rec. Geol. Surv. Ind.*, vol. x, pp. 204–223 (1877).

advanced, of the static condition of compression, lateral and vertical, until the diminution of the latter factor permitted movement in restoration of equilibrium.

It is, however, conceivable that eventually the conditions of equilibrium may be narrowed to the difference of vertical pressure in a valley and on the adjoining hills, so that an anticline may exhibit steep crestal dips in hard beds exposed in the floor of a transverse valley, whilst the higher ground on either side shows softer beds following a more uniform curve. In that case the normal rule of taking the reading of the more deeply-seated beds, as less accessible to recent meteorological action (soil-creep, land-slip and the like), would lead to error. Every instance must be judged according to special conditions observable, and the general character of the district. A few sharp-crested folds in a region generally of gentle flexure might rightly be held as evidencing merely recent and perhaps wholly superficial readjustment of position, whilst the prevalence of acute curves would nullify occasional appearances of more gradual folding.

THE LIBRARY.

List of Books Received.

The nucleus of a Library has been formed, and it is hoped that Members will contribute books, pamphlets, &c., pertaining to the Petroleum Industry.

All such gifts will be acknowledged in the Journal.

The Library on November 1st, 1914, comprised the following works. The name of the donor is appended in every case.

Cassier's Engineering Monthly, London. Vol. XLIV, Nos. 3–6; XLV, Nos. 1–6; and XLVI, Nos. 1–4.
By Arthur W. Eastlake.

Cassier's Magazine, London. Vol. XLIII, No. 3 (Oil Power Number). By Arthur W. Eastlake.

Geological Survey of India. Records, Vol. XLIV, Part 2, 1914. By the Director.

Imperial Institute. Bulletin, Vol. XII, Nos. 2 and 3.
By the Director.

Institute of Chemistry of Great Britain and Ireland. History of the Institute, 1877–1914. By the Institute.

—— Register of Fellows, Associates and Students. August, 1914. By the Institute.

Japan, Mining in, Past and Present. The Bureau of Mines, 1909. By C. B. Rosenplaenter.

Junior Institution of Engineers. Journal and Record of Transactions, Vol. XXIV, Part 3, December, 1913.
By the Institution.

Laws for Plugging Oil and Gas Wells in California, Illinois, Indiana, Kansas, Kentucky, Michigan, New York, Ohio, Oklahoma, Pennsylvania, Utah, Texas, West Virginia, and Wyoming. By the Oil Well Supply Co.

PAPUA. Bulletin of the Territory, No. 1, 1913. Notes on the occurrence of Coal, Petroleum and Copper. By J. E. Carne, F.G.S. By the High Commissioner for Australia.

PETROLEUM, LONDON. Vols. I, II, III. (1900–1903). By Arthur W. Eastlake.

SOCIETY OF CHEMICAL INDUSTRY. Journal, Vol. XXXII, 1913. By C. B. Rosenplaenter.

WYOMING. Geology and Mineral Resources of a Portion of Fremont County, Wyoming. Wyoming State Geologist, Bull. 2, Series B, 1912. By C. E. Jamison. By C. B. Rosenplaenter.

WYOMING. United States Geological Survey, Bull. 452, 1911. The Lander Oilfields, Fremont County, by E. G. Woodruff, and the Salt Creek Oilfield, Natrona County, by C. H. Wegemann. By C. B. Rosenplaenter.

List of Honorary Members, Members, Associate Members, Students, and Associates of The Institution of Petroleum Technologists.

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1913	§Engler, Geheimer Rat *Professor* Dr. Carl, Kaiserstrasse 12, Karlsruhe i/B., Germany.
	MEMBERS. (M.Inst.P.T.)
1913	*Adams, Alfred C., (*Member of Council*), 101, Leadenhall Street, London, E.C.
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1913	*Armstrong, James Tarbotton, 22, Great St. Helen's, London, E.C.
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1914 †Bailey, Tom Esmond Geoffrey, F.G.S., c/o Anglo-Saxon Petroleum Co., Ltd., Miri, Sarawak.

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1913 §Beazley, Arthur T., B.Sc., Assoc.M.Inst.C.E., c/o California Oilfields, Ltd., Coalinga, California, U.S.A.

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1914 §Bird, William Loraine Wilberforce, Winchester House, Old Broad Street, London, E.C.

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1913 §Bosworth, Dr. T. O., B.A., D.Sc., F.G.S., 12, St. Giles Street, Northampton.

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1914	†Hunting, Percy Llewellyn, Milburn House, Newcastle-on-Tyne.

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1914 †MacKenzie, Robert Harman, 93, Coleherne Court, Earls Court, London, S.W.

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1914 †Penny, Frederick Willoughby, F.G.S., c/o Rumanian Consolidated Oilfields, Ltd., Ploesti, Rumania.

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1914 Schwarz, Theodore, c/o Soc. Frank Russell, Campina, Rumania.

1913 §Stigand, Ivan Ascanio, B.A., F.G.S., Royal Societies Club, St. James's Street, London, S.W.

1914 †Templeton, John Clark, c/o L. L. Andreis, Ekaterinodar, South Russia.

1913 §Walker, A. Gordon, A.M.Inst.M.E., c/o Magyar Karpati Petroleum R. T., Izaszacsal, Maramaros m, Hungary.

1913 §Whyte, J. M., Minatitlan Refinery, Minatitlan, Vera Cruz, Mexico.

1914 †Willans, Charles Turner, A.M.I.Mech.E., 31, Museum Chambers, Bury Street, Bloomsbury, London, W.C.

1914 Willcox, Walter Henry, c/o Messrs. W. H. Willcox & Co., Ltd., 38, Southwark Street, London, S.E.

STUDENTS. (Stud.Inst.P.T.)

1914 Atherton, Charles William, The University Club, Edgbaston, Birmingham.

1914 Bouchier, John Rickman, Rose Cottage, West Street, Carshalton, Surrey.

1914 Butlin, John Arundel, 17, Stanmore Avenue, Port of Spain, Trinidad.

1914 †Cochrane, Thomas George Frederick, Crawford Priory, Springfield, Fife, Scotland.

1913 §Eastlake, Arthur Lloyd, c/o Messrs. W. J. Fraser & Co., Ltd., Dagenham, Essex.

1914 †Guttentag, Wilfred Emil, A.R.S.M., c/o Rumanian Consolidated Oilfields, Ltd., Targoviste, Rumania.

1914 †Houghton, Douglas Lutman, 'Woodthorpe,' Acacia Road, Acton, London, W.

1914 †di Mendonça, Manuel Santos, 80, Harrow Road, Birmingham.

1914 †Orme, Charles Temple, A.M.I.Mech.E., M.J.I.E., 213, Uxbridge Road, Shepherd's Bush, London, W.

1913 §Phillips, Carl, c/o The Burmah Oil Co., Ltd., P.O. Box 67, Rangoon, Burma.

1914 †Redwood, Ivor Charles, 2, West Ascent, St. Leonards-on-Sea.

1914 †Rosas, Augustin, The University, Edgbaston, Birmingham.

1914 †Stileman, Richard, 'Grasscroft,' Weston-Super-Mare.

1914 †Strickland, Alan Faulkner, Stud.Inst.M.M., 'The Lodge,' Wimbledon Common, Surrey.

1914 †Watts, Kenneth, Krimskaya, Kuban Province, South Russia.

ASSOCIATES. (Assoc.Inst.P.T.)

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1914 †Bishop, Frederick William, F.C.I.S., 145, Dashwood House, New Broad Street, London, E.C.

1914 †Darch, Francis William, M.I.L.S., 20, Eastcheap, London, E.C.

1914 †Foster, Bertram Egerton, 82, Victoria Street, Westminster, London, S.W.

1914 †Head, Ernest Edward, 24, St. Mary Axe, London, E.C.

1914 Maggs, Frederick Richards, M.Pharm.Soc., 78, Cromwell Road, London, S.W.

1914 †Mancell, George William, 9, Martins Lane, Cannon Street, London, E.C.

1914 Milne, Frederick John, c/o Milne & Co., Lima, Peru.

SUMMARY.

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Associate Members	48
Students	15
Associates	8
Total	165